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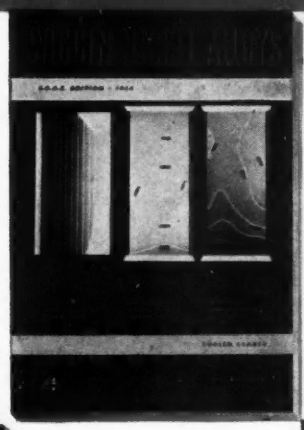

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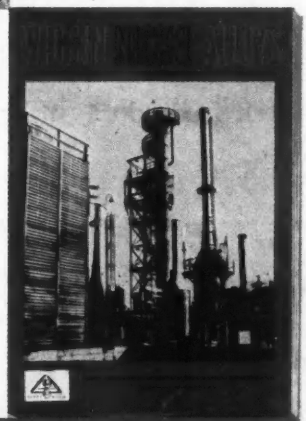

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1955

THE ENGINEER

MARCH 25, 1955

Institution of Mechanical Engineers

THE 108th annual general meeting of the Institution of Mechanical Engineers was held at the Institution's headquarters in Birdcage Walk, Westminster, last Friday evening. The report of the council for 1954 was presented, and extracts from it are printed on page 420 of this issue. The result of the ballot for the election of the council for 1955 was made known, Mr. P. L. Jones, Wh. Ex., being elected as president in succession to Dr. R. W. Bailey. Mr. Jones is a director of Swan, Hunter and Wigham Richardson, Ltd., and of Wallsend Slipway and Engineering Company, Ltd. He was elected an associate member in 1915 and became a full member of the Institution in 1932. Mr. Jones has served on the council since 1946. Mr. G. Varley, chief engineer of Dodd Investments, Ltd., and Mr. H. Desmond Carter, managing director of Crossley Brothers, Ltd., were elected vice-presidents, and the following have been elected to the council :—Mr. R. C. Bond, Major-General W. A. Lord, C.B., Dr. W. Ker Wilson, Mr. H. Norman G. Allen, Dr. T. W. F. Brown, Mr. G. B. R. Feilden, and Mr. P. McGregor Ross. This year's summer meeting of the Institution is to be held at Southampton from Tuesday to Friday, July 5th to 8th.

Machine Tool Equipment for Varied Demand

A THREE-DAY conference on management, organised jointly by the British Institute of Management, the Federation of British Industries and the National Union of Manufacturers, was held at Southport last week-end. One of the papers, presented to the conference by Mr. J. A. C. Atkins, was entitled "Equipment for Varied Demand : The Need of the Smaller Company." In introducing this paper, Mr. Atkins pointed out that it was inevitable that mass production should be undertaken by large firms with specialised equipment, and in general the smaller firms could not compete in this field. The smaller concern had, therefore, to undertake the production of varied work in smaller quantities for which the special equipment of the larger firm was not economically or easily adaptable. This class of work made the machine tool requirements of a small firm inconsistent, and the case often arose where certain primary kinds of machine stood idle, or jobs were held up, because insufficient numbers of other machines were not available. For this reason it would be advantageous to have available machine tools of more universal design and adaptable for more than one class of work in the small shop. Mr. Atkins traced the evolution of machine tools and pointed out that most of them, including the lathe, grinding machine, boring machine, milling machine, planing macaine and shaping machine, were variations and elaborations of the simple treadle lathe. The family likeness of these machines was still there, but the functions had become so varied that they could not generally be adapted to do different classes of work. He then traced the steps which had been made towards the development of more universal machines, such as unit construction, and pointed out certain disadvantages. As it was apparent that the types of machine tool available to-day were too single purpose for the small firm, Mr. Atkins went on to discuss the possibility of designing a more universal machine in which the properties of the lathe, grinder, miller and borer could be combined. The machine suggested was basically a combination of the surfacing, sliding and screw-cutting lathe, and the cylindrical and commercial thread grinding machines with a number of tool heads for external and internal grinding, thread grinding and turning attached to a fairly large compounding sliding table. It was pointed out that the capital cost of such a universal machine would be higher than the average conventional machine of to-day, but that its greater flexibility should more than compensate for the added cost.

Shortage of Science Teachers

DURING a speech which he made in Birmingham last Friday, Sir Harry Pilkington, president of the Federation of British Industries, referred to the inquiry into the shortage of science teachers which the F.B.I. initiated about a year ago. He commented also on the letter on the subject which has been circulated to members of the Federation, and which was mentioned in our last issue. Sir Harry emphasised the necessity to recruit more science teachers and said that industry must now do with less really well qualified science-trained people than it would like. An important part of the recommendations made in the report following the recent F.B.I. inquiry was that the position of science teachers must be made financially more attractive. That recommendation has been accepted, and industry, Sir Harry urged, must not now make it impossible of fulfilment. Industry must not increase once more the disparity between the remuneration and conditions of service it offered and those offered by the teaching profession. Sir Harry went on to say that there could be no question of establishing a clear scale of salaries applicable throughout industry, or of freezing the number of science graduates in any firm at its present level. In this matter, however, with its effect not only on inflationary spirals now but on the supply of young men for the next generation, it must be realised that there were not enough scientists to go round. The supply of scientists, Sir Harry observed, could not be augmented quickly, and teachers were as important as research workers and technicians. There must, therefore, be a general policy of moderation and restraint all round. Industry must make quite certain that it was using scientists, all the time, on work worthy of their skill and their training.

Purity of London Waters

THE Metropolitan Water Board has published its thirty-fifth report on the results of bacteriological, chemical and biological examination of London Waters for the years 1947–52. The report is written by Lt.-Col. E. F. W. Mackenzie, who recently retired from the position of director of water examination to the Board. Lt.-Col. Mackenzie joined the Board in 1939, and in this report he recalls the difficulties in furthering public health during the war, and the advances since made in water treatment, of which the introduction of superchlorination, in 1949, was of particular note. Since that time there has been virtually no chlorine in the water supplied to London, and of 47,438 samples examined, 99·84 per cent have been of the highest standard of bacterial purity. Problems caused by the flooding of the Lee Bridge works in March, 1947, are discussed in some detail in the report, and there is also comprehensive accounts of other water purification problems. For instance, at Kempton Park, full-scale experimental work has been in progress for some time on the classification of river-derived supplies with coagulants. The use of micro-strainers as an alternative to primary filtration has also been promoted by the Board, which suggested their manufacture some years ago. Extensive experiments have since been carried out and it is concluded that the choice between micro-strainers and primary filters in conjunction with slow sand filters would appear to rest more upon engineering than upon other considerations. Other experimental work on micro-strainers, such as for removing algae, is still in its infancy, the report states. The report contains detailed chemical, bacteriological and biological sections, and notes on the automatic sampling of water and the dilution of flow underground with sodium phosphate.

British Plastics Federation Report for 1954

IN the annual report recently published by the British Plastics Federation, twenty-one years' history of the Federation is briefly reviewed. The Federation's most noticeable achievement, the report stated, had been the expansion of its technical work to keep pace with the rapid growth of the industry during the past ten years. It noted that in 1943 there were only two technical committees, as against the thirty-three active technical committees and sub-committees and seventeen B.S.I. plastics committees of to-day. Membership now stood at 294, ten higher than a year ago. The activities mentioned in the report refer to the completion of a case in the Science Museum, South Kensington, illustrating the processing of plastics ; the compilation of a new edition of the Buyers Guide, and a code of practice for annealing polystyrene, both shortly to be published ; the Surface Coating Resin Index, just published ; and work on the drafting and revision of numerous British Standard Specifications. The sale of abstracts, it was stated, reached a record figure in 1954. At the annual general meeting last week, the council elected Mr. W. Charles Waghorn as president ; Mr. A. E. Skan was re-elected chairman, Mr. C. C. Last, vice-chairman, and Mr. H. W. Graesser-Thomas, hon. treasurer.

National Factory Equipment Exhibition

THE Third National Factory Equipment Exhibition will be opened at Earls Court, London, on Monday next, March 28th, by Sir Miles Thomas. This exhibition, which will be open daily until Saturday, April 2nd, is designed to present to industrial executives the most up-to-date methods and equipment developed for promoting economy and efficiency in factory management and production. The exhibits will deal with the latest forms of design, construction and materials for new factories ; factory services and maintenance equipment ; labour-saving methods in the handling and storage of goods ; welfare and safety equipment and organisation ; production and stock control systems ; the organisation of administrative offices and drawing offices, &c. During the course of the exhibition a number of conferences on industrial problems will be held. One of these conferences, which will deal with work study, has been arranged by the British Productivity Council, and will be held on Monday, March 28th, and Wednesday, March 30th. On Tuesday, March 29th, a conference on the subject of fuel efficiency will be held jointly by the National Industrial Fuel Efficiency Service and the Combustion Engineering Association. In the course of this conference, the following papers will be presented : "Reducing Steam Raising Costs," by Mr. John Rylands ; "Economics of Power Supply," by Mr. P. F. Morgan ; "Steam Saving Pays," by Sir Oliver Lyle ; and "N.I.F.E.S.' Contribution to Fuel Efficiency," by Mr. L. W. Jenkins. The Institution of Works Managers will hold a conference on "Maintaining Prosperity" by 'Efficient Management," on Thursday, March 31st, Friday, April 1st and Saturday, April 2nd.

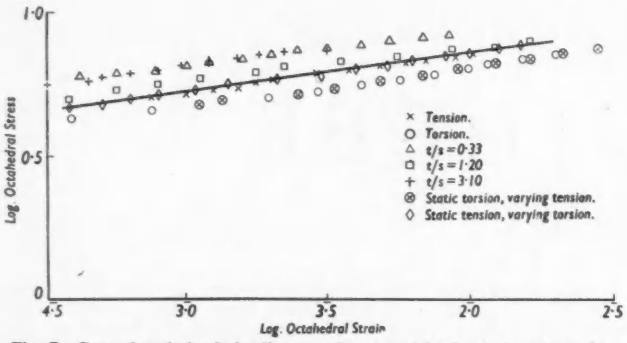


Fig. 7—General and simple loading complex stress/plastic strain relations for RR59 aluminium alloy at 20 deg. Cent.

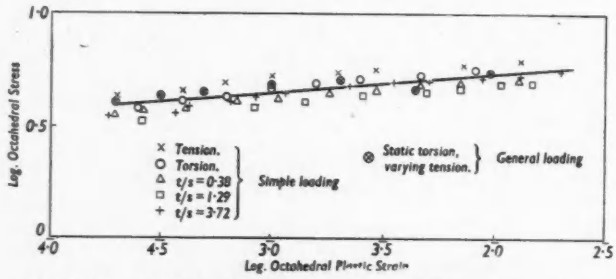


Fig. 8—General and simple loading complex stress/plastic strain relations for RR59 aluminium alloy at 200 deg. Cent.

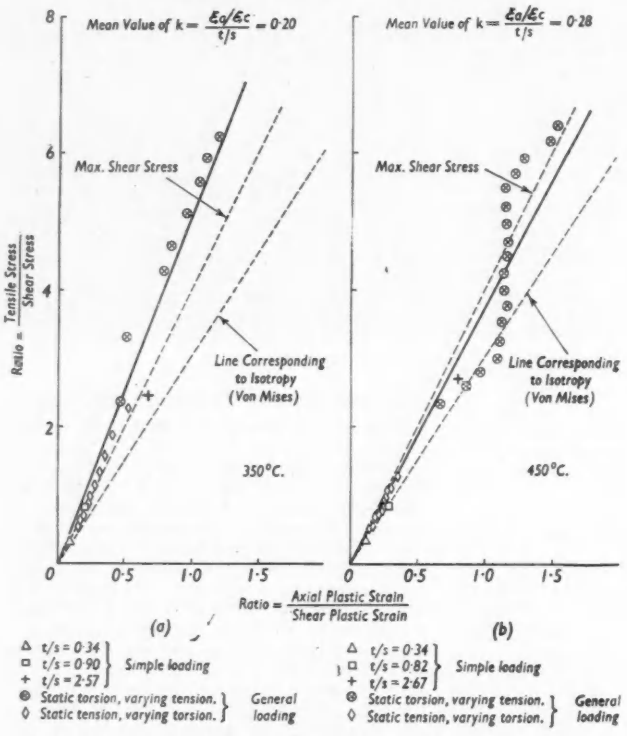

Mean Value of k = Ea/Ec / t/s = 0·20
Mean Value of k = Ea/Ec / t/s = 0·28
Max. Shear Stress
Line Corresponding to Isotropy (Von Mises)
350°C.
450°C.
Ratio = Tensile Stress / Shear Stress
Ratio = Axial Plastic Strain / Shear Plastic Strain
(a)
(b)
△ t/s = 0·34
□ t/s = 0·90
+ t/s = 2·57
Simple loading
⊗ Static torsion, varying tension.
◇ Static tension, varying torsion.
General loading
△ t/s = 0·34
□ t/s = 0·82
+ t/s = 2·67

Fig. 9—General and simple loading complex stress/plastic strain relations for 0·17 per cent C steel at 350 deg. Cent. and 450 deg. Cent.

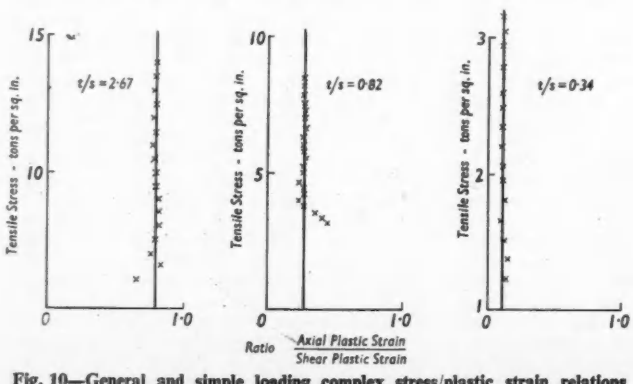


Fig. 10—General and simple loading complex stress/plastic strain relations for 0·17 per cent C steel at 450 deg. Cent.

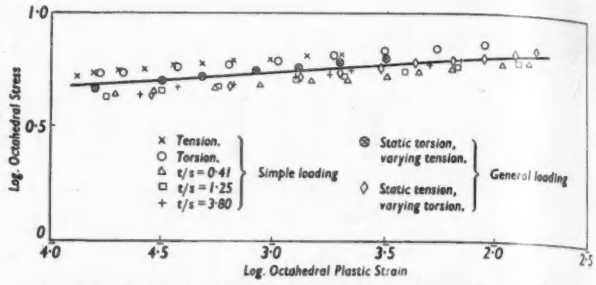


Fig. 11—General and simple loading complex stress/plastic strain relations for RR59 aluminium alloy at 150 deg. Cent.

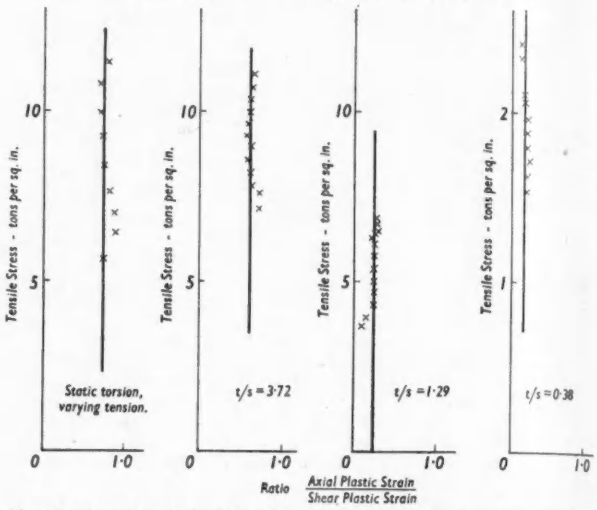

Tensile Stress - tons per sq. in.
Static torsion, varying tension.
t/s = 3·72
t/s = 1·29
t/s = 0·38
Ratio Axial Plastic Strain / Shear Plastic Strain

Fig. 12—General and simple loading complex stress/plastic strain relations for RR59 aluminium alloy at 200 deg. Cent.

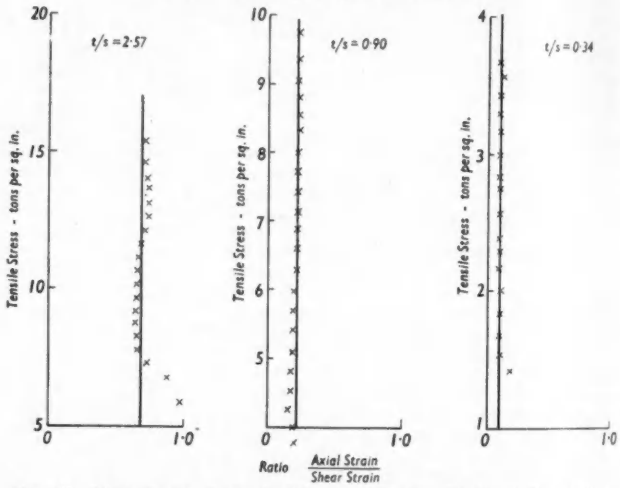


Fig. 13—General and simple loading complex stress/plastic strain relations for 0·17 per cent C steel at 350 deg. Cent.

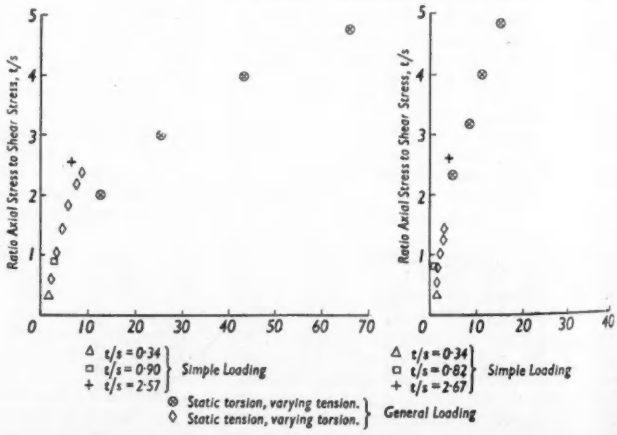


Fig. 14—General and simple loading complex stress/plastic strain relations for 0·17 per cent C steel at 350 deg. Cent. and 450 deg. Cent. Variation of anisotropy constant with ratio of axial to shear stress

Plastic Strain and Stress Relations at High Temperatures

By A. E. JOHNSON, D.Sc., M.Sc.Tech., M.I.Mech.E., N. E. FROST, B.Sc., A.M.I.Mech.E., and J. HENDERSON, B.Sc.*

No. II—(*Continued from page* 368, *March 18th*)

The work described in this article is a further portion of a general research into the short-time combined stress properties of metallic alloys. It comprises tests made to determine the plastic-strain-stress relations for a 0·17 *per cent C steel at* 350 *deg. and* 450 *deg. Cent., and an RR59 aluminium alloy at* 20 *deg.,* 150 *deg. and* 200 *deg. Cent., under both simple and general complex stress loading conditions. A previous paper (Ref.* [1]*) dealt with the plastic-strain-stress relations for a magnesium alloy at* 20 *deg.,* 50 *deg.,* 100 *deg., and* 150 *deg. Cent. As in the case of the magnesium alloy the intent of the authors has been to explore such a range of plastic strain (*1 *to* 2 *per cent maximum) as may reasonably be expected to occur at the commencement of a normal creep test ; in this sense the short time investigation is supplementary to a combined stress-creep programme. Only a selection of diagrams of results is reproduced. The full set can be examined by application to the authors.*

RR59 Alloy at 20 deg., 150 deg. and 200 deg. Cent.

As in the case of the 0·17 per cent C steel, investigation of the form of application of the octahedral stress criterion showed that a log octahedral stress/log octahedral plastic strain plot of the data gave the best representation, and this plot is shown in Figs. 7, 8 and 11. The experimental points for individual tests are here dispersed over a greater range of strain at the various stress levels than in the case of the 0·17 per cent carbon steel, and this is probably emphasised by the fact that the apparent stress dependence of the strain is here of order 10, as compared with 5 for the carbon steel. Consideration of the three sets of results taken together, however, indicate that the relative disposition of the lines for the various tests is of a random nature, the order of tests corresponding to particular stress ratios being altered in each of the three sets. Additionally one or two repeat tests (not shown in the tables) indicated that the disparity between corresponding tests on two different specimens was of the same order as that between the various tests at differing stress ratios shown in Figs. 7, 8 and 11. Accordingly, differences of individual specimen material must be held responsible for the random disposition of the lines, and the results of the tests should be viewed in this light. Incidentally, it is worth emphasising here that these differences are invariably capable of expression by the purely arithmetical coefficients of the stress/plastic strain relations, and do not appreciably affect the power exponents.

It should be mentioned that when this RR59 aluminium alloy material was first used for combined stress creep tests careful initial checks of the similarity of the material behaviour in various directions of the continuous casting were initially made, and were found to give very satisfactory results, and this similarity was confirmed by the subsequent observations of the combined stress tests.

On the basis of this performance the casting used for the present tests was rather taken on trust, and initial tests of similarity were not made. Unfortunately, the high standard of specimen similarity displayed previously does not appear to have been reproduced. However, despite these facts, Figs. 7, 8 and 11 show that, as in the case of the 0·17 per cent C steel, the log log lines representing the general loading tests lie within the range of the family of simple loading tests. Thus, despite the relative scatter of these results, there is no evidence afforded to discount the conclusion reached in the previous paragraph for the 0·17 per cent C steel, that the behaviour of the RR59 aluminium alloy material may be expressed by the use of the same type of deformation equation with a degree of accuracy within the limits of reproducibility of individual tests for the experimental range concerned. The form of these relations expressed in terms of principal stress and strain is of the same general type as indicated for the 0·17 per cent C steel, the mean values of n_1 and A_1 being as indicated in Table 1.

In conformity with the proceeding in the case of the 0·17 per cent C steel, the family of lines at 20 deg., 150 deg. and 200 deg. Cent. are characterised (for corresponding reasons) by a mean line corresponding to the average A_1 mentioned above.

Consideration of Anisotropy Arising During Plastic Strain

For materials such as those at present under consideration, in which deformation appears to follow the Mises or shear strain energy criterion of plastic strain, it can be shown that in tests on thin-walled tubular specimens under axial tension and torsion the ratio of axial to shear strain should have the value $t/3s$, where t and s are the tensile and shear stresses, providing the material remains isotropic. Corresponding to this relation, principal strains will be proportional to the unmodified stress deviators of each stress

* Mechanical Engineering Research Laboratory, Mechanics and Materials Division, East Kilbride.

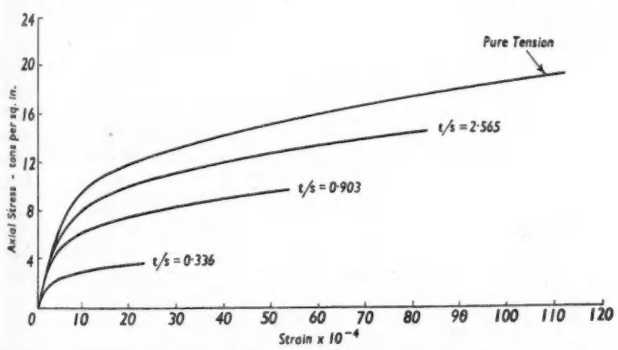


Fig. 15—Stress/plastic strain relations for 0·17 per cent C steel at 350 deg. Cent. Total axial strain in simple loading tests

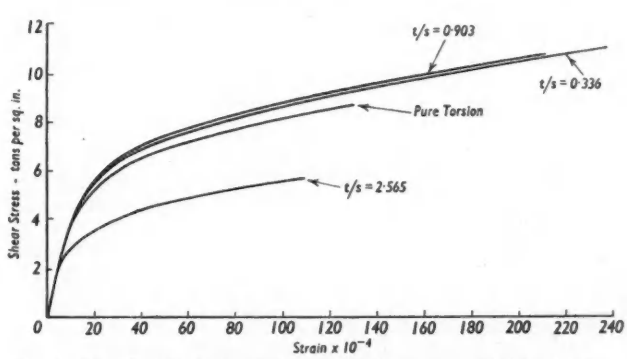


Fig. 16—Stress/plastic strain relations for 0·17 per cent C steel at 350 deg. Cent. Total shear strains in simple loading tests

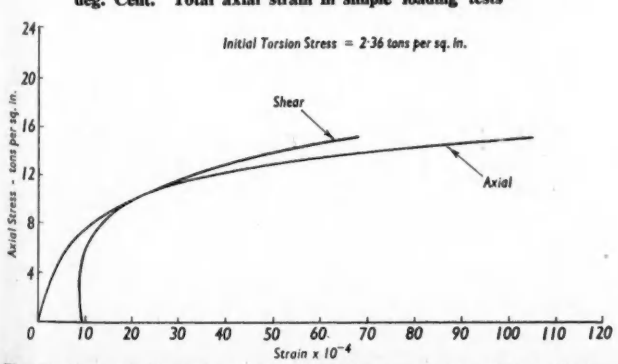


Fig. 17—Stress/plastic strain relations for 0·17 per cent C steel at 450 deg. Cent. Total axial and shear strain in general loading test. Static torsion ε varying tension

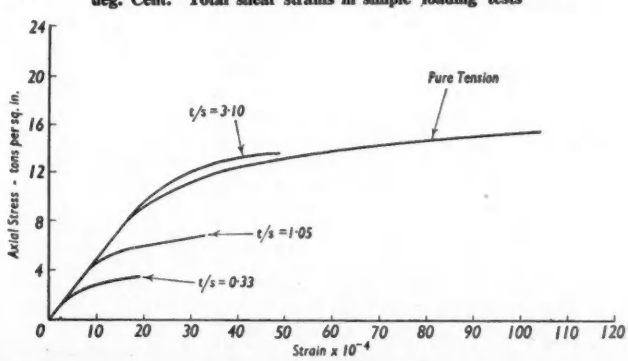


Fig. 18—Stress/plastic strain relations for aluminium alloy RR59 at 20 deg. Cent. Total axial strains in simple loading tests

system. In Figs. 15–21 values of axial (ϵ_a), shear (ϵ_c) are given, and in Figs. 9, 10, 12, 13, and 23–25 values of the ratio ϵ_a/ϵ_c are given.

Consideration of these values indicates that the above criterion of isotropy is not fulfilled, and accordingly since the evidence is that the Mise criterion is well fitted to the materials, the conclusion must be reached that anisotropy due to deformation arises in the tests in general, the nature of this anisotropy is considered for each of the two materials in the following paragraphs.

portion of the principal stress strain relations which become

$$\epsilon_1 = A_1[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_1-\sigma_2)-(\sigma_3-\sigma_1)]$$

$$\epsilon_2 = A_1[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[B(\sigma_2-\sigma_3)-(\sigma_1-\sigma_2)]$$

$$\epsilon_3 = A_1[\Sigma(\sigma_1-\sigma_2)^2]^{n_1}[(\sigma_2-\sigma_1)-B(\sigma_2-\sigma_3)]$$

where B has the values given in Figs. 14 and 22, being unity in the two cases where isotropy is approached. This type of anisotropy characterised the complex stress/creep strain relationship for high stresses for this material.

ratios ϵ_2/ϵ_1 and ϵ_3/ϵ_1 and is measured by B, which changes considerably as t/s increases. Accordingly for this material it appears to be reasonably well established that, whatever the nature of the test, the ratio ϵ_a/ϵ_c is a constant proportion of the ratio t/s, being about 0·28. This fact taken in accordance with the information concerning the representation of the state of anisotropy by one coefficient derived from the simple loading tests enables

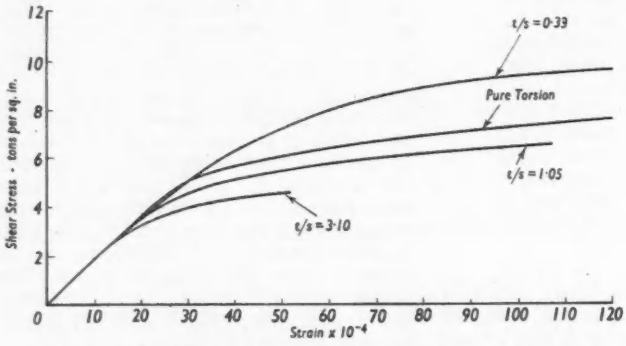


Fig. 19—Stress/plastic strain relations for aluminium alloy RR59 at 20 deg. Cent. Total shear strains in simple loading tests

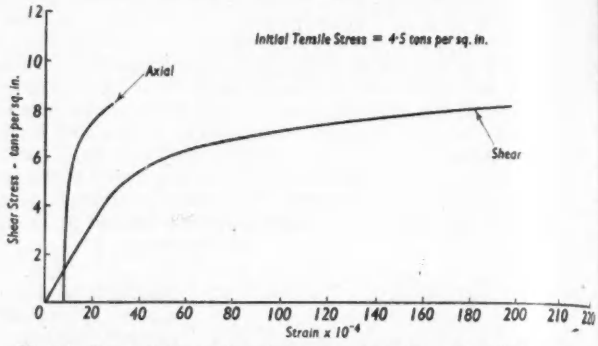


Fig. 20—Stress/plastic strain relations for aluminium alloy RR59 at 150 deg. Cent. Total axial and shear strains in general loading test. Static tension varying torsion

0·17 Per Cent C Steel

Consideration of the simple loading tests for this material at 350 deg. Cent. and at stress ratios of t/s=0·34, 0·90, and 2·5 indicated that the corresponding values of

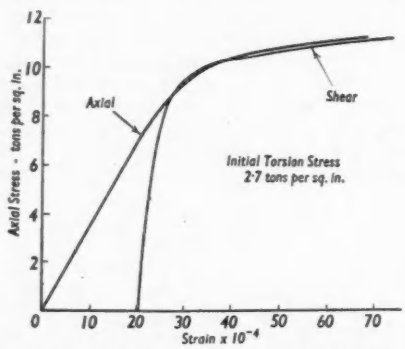


Fig. 21—Stress/plastic strain relations for aluminium alloy RR59 at 200 deg. Cent. Total axial and shear strains in general loading tests. Static torsion varying tension

ϵ_a/ϵ_c are 0·084, 0·22, and 0·70. These differ appreciably from the values expected on the basis of the assumption of isotropy. Again at 450 deg. Cent., and for values of t/s=0·34, 0·82, and 2·67, the ratio ϵ_a/ϵ_c has the values 0·115, 0·275, and 0·80. The first two of these are values close to those required by isotropy, the third shows some departure from the isotropic value. Accordingly it is apparent that on the basis of the simple loading tests the 0·17 per cent C steel is anisotropic at 350 deg. Cent. and under the stress systems up to t/s=2·67 concerned in the simple loading tests, and at 450 deg. Cent is only slightly anisotropic in a similar range of stress systems. It is to be noted at this point that the values of the ratio t/s made use of in the general loading tests considerably exceed those occurring in the simple loading tests.

Consideration of the principal strain ratios ϵ_2/ϵ_1 and ϵ_3/ϵ_1 in the above group of tests indicated that the anisotropy could in all cases be represented by the introduction of one anisotropy coefficient B in the stress deviator

Having apparently satisfactorily represented the anisotropy in the case of simple loading, it is now necessary to see how the general loading tests behave. First of all, reference back to the simple loading tests, indicates that the values of ϵ_c/ϵ_a, although in most cases not corresponding to the isotropic t/s ratio, are nevertheless approximately proportional to t/s. In Fig. 9 the ratio t/s is plotted against ϵ_a/ϵ_c for all tests, both simple and general loading, and at both temperatures. It is obvious from these two plots that the linear variation ϵ_a/ϵ_c with t/s is a general relation, and that the values for individual simple loading tests, and those at specific levels of t/s in the general loading tests, are probably in the nature of deviations from a general value. In Fig. 9 mean lines are drawn which represent the mean relation of ϵ_a/ϵ_c to t/s, i.e.

$$\frac{\epsilon_a/\epsilon_c}{t/s} = k.$$

It appears that at both temperatures k has a value of about 0·28. It must be emphasised here that the constant relation between ϵ_a/ϵ_c and t/s does not mean a constant state of anisotropy. Anisotropy depends on the

the state of anisotropy in the general loading tests to be precisely represented and predicted from the state revealed by the simple loading tests.

It may be shown that if ϵ_a/ϵ_c has a constant value K, and if anisotropy be represented by the system previously outlined involving one anisotropy coefficient B only, then B can be expressed entirely in terms of $t/s=c$ and of K.

The relation obtained is actually

$$B = \frac{\sqrt{c^2+4}[20K-6c]-2c^2-4+4Kc}{[c-\sqrt{c^2+4}][4K+\sqrt{c^2+4}-c]}$$

If further $K=kc$, as has been demonstrated in the present series of tests, then B for any test or t/s level in general loading tests merely becomes

$$B = \frac{c\sqrt{c^2+4}[20k-6]-2c^2-4+4kc^2}{[c-\sqrt{c^2+4}][4kc+\sqrt{c^2+4}-c]}.$$

It is thus possible for this material to specify entirely the stress/plastic strain relations for general loading conditions on the basis of information obtained from simple loading tests, over the experimental range concerned.

RR59 Alloy at 20 deg., 150 deg. and 200 deg. Cent.

Here consideration of the values of ϵ_a/ϵ_c in relation to t/s for the simple loading tests

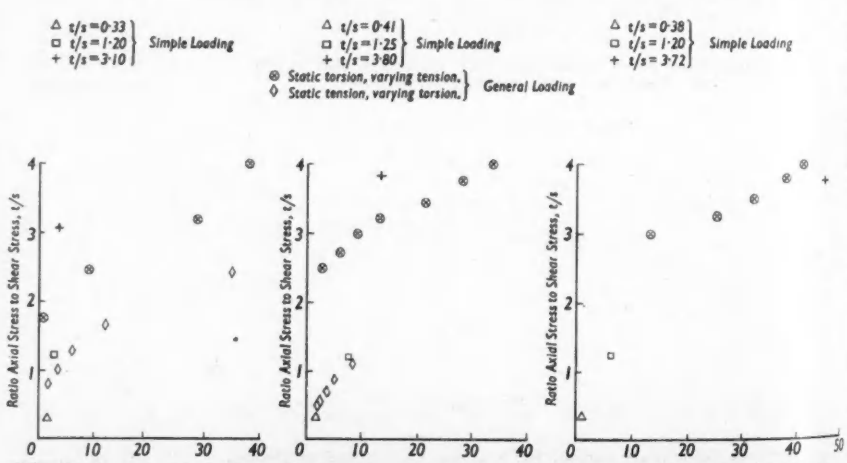


Fig. 22—General and simple loading, complex stress/plastic strain relations for RR59 alloy at 20 deg., 150 deg. and 200 deg. Cent. Variation of anisotropy constant with ratio of axial to shear stress

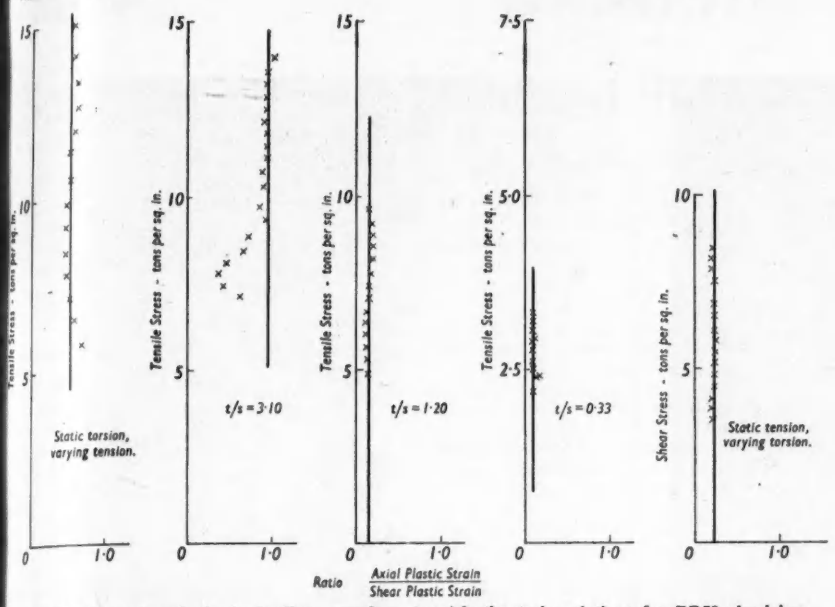

Tensile Stress - tons per sq. in.
Shear Stress - tons per sq. in.
Static torsion, varying tension.
t/s = 3·10
t/s = 1·20
t/s = 0·33
Static tension, varying torsion.
Ratio Axial Plastic Strain / Shear Plastic Strain

Fig. 23—General and simple loading, complex stress/plastic strain relations for RR59 aluminium alloy at 20 deg. Cent.

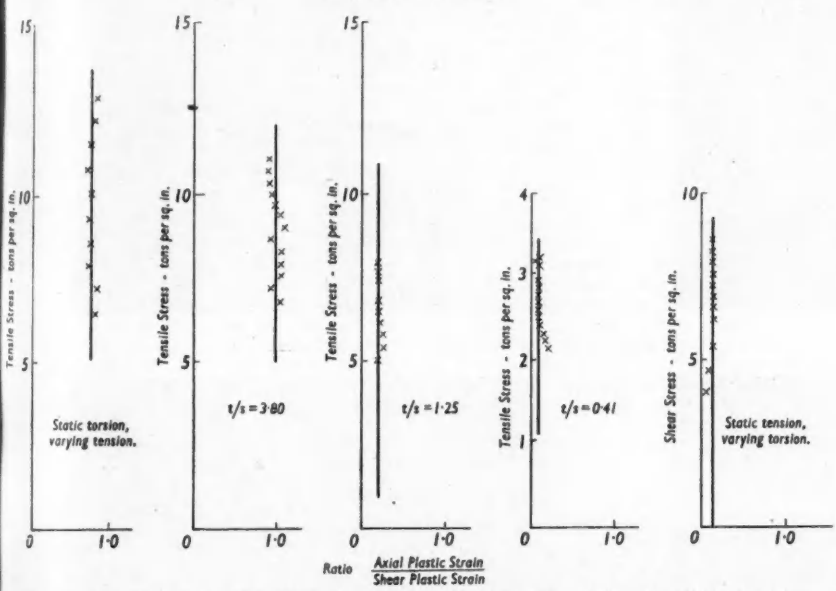

Tensile Stress - tons per sq. in.
Shear Stress - tons per sq. in.
Static torsion, varying tension.
t/s = 3·80
t/s = 1·25
t/s = 0·41
Static tension, varying torsion.
Ratio Axial Plastic Strain / Shear Plastic Strain

Fig. 24—General and simple loading, complex stress/plastic strain relations for RR59 aluminium alloy at 150 deg. Cent.

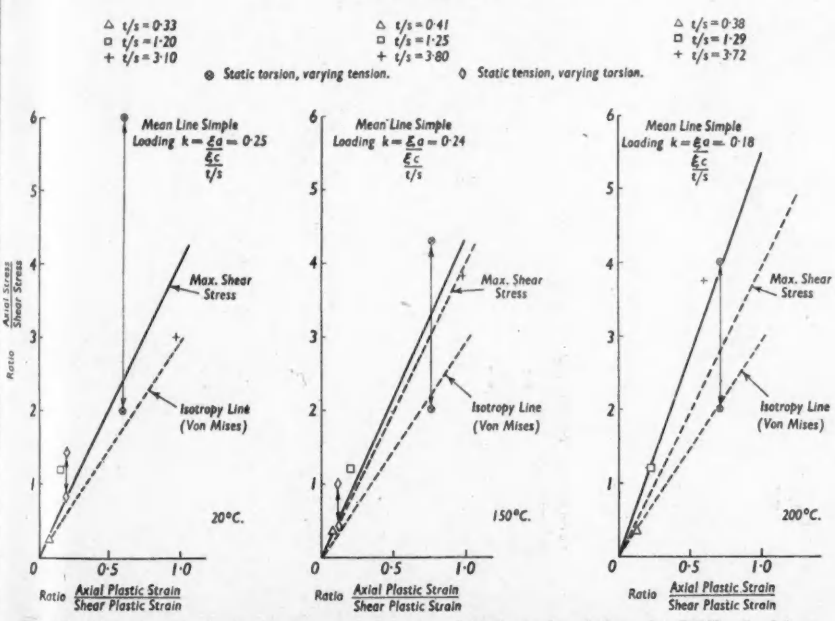

△ t/s = 0·33
□ t/s = 1·20
+ t/s = 3·10
⊗ Static torsion, varying tension.
△ t/s = 0·41
□ t/s = 1·25
+ t/s = 3·80
◊ Static tension, varying torsion.
△ t/s = 0·38
□ t/s = 1·29
+ t/s = 3·72
Mean Line Simple Loading k = ξa/ξc = 0·25 / t/s
Mean Line Simple Loading k = ξa/ξc = 0·24 / t/s
Mean Line Simple Loading k = ξa/ξc = 0·18 / t/s
Max. Shear Stress
Isotropy Line (Von Mises)
20°C.
150°C.
200°C.
Ratio Axial Stress / Shear Stress
Ratio Axial Plastic Strain / Shear Plastic Strain

Fig. 25—General and simple loading, complex stress/plastic strain relations for RR59 aluminium alloy at 20 deg., 150 deg. and 200 deg. Cent.

at all three temperatures indicates that the values deviate from those required by isotropy, and gives some indication that as in the case of the 0·17 per cent C steel they are roughly proportional to t/s. The relative roughness compared with the 0·17 per cent C steel ratios might reasonably be explained on the basis of the greater material variation from specimen to specimen.

Turning now to the general loading tests a surprising fact will be noted. Instead of (as in the case of the 0·17 per cent C steel) following the linear variation with t/s on similar lines to the simple loading tests, it is seen that in these tests the ratio ϵ_a/ϵ_c takes up a new value immediately, or very soon after the tests start whatever the stress ratio. The position is well illustrated by Fig. 25, in which the simple loading test values of ϵ_a/ϵ_c are compared with t/s, and as indicated above are found to lie roughly along mean lines giving values of k of about 0·25, 0·24 and 0·18 at the three temperatures. The constant values of ϵ_a/ϵ_c with t/s in the general loading tests are indicated by the vertical lines covering the range of values of t/s corresponding to the test. The practical upshot of these facts is that in contrast with the case of the 0·17 per cent C steel the details of the anisotropy in the general loading tests cannot be predicted from the simple loading tests.

However, this is in effect a serious loss in the academic sense only, since the system of anisotropy being what it is, the strain in the major principal stress direction, which is in general the maximum unit positive strain occurring at any t/s level in the general loading system is independent of the anisotropy coefficient, and may therefore as in the case of the 0·17 per cent C steel be predicted directly not only from simple loading tests, but, of course, from simple tensile and torsion tests.

REFERENCE

[1] "Stress and Plastic Strain Relations of a Magnesium Alloy," by A. E. Johnson and N. E. Frost, THE ENGINEER, November 28, 1952, page 713.

(To be concluded)

Town Gas from Oil

IT is announced that the South Eastern Gas Board and the British Petroleum Company, Ltd., have agreed jointly to examine the practicability of building a plant to convert petroleum products available at the Kent oil refinery to town gas of acceptable quality. The Gas Board developed the Segas process of catalytic oil gasification, which is capable of using a wide range of products from butane to heavy fuel oil and of producing town gas.

It is proposed that the installation should be situated at and operated in conjunction with the Kent oil refinery. It is expected that the initial installation would convert some 50,000 tons of petroleum products a year to gas. It would have a daily output of 15,000,000 cubic feet of gas and be arranged for extension to a capacity of 40,000,000 to 45,000,000 cubic feet daily with an annual petroleum usage of up to 150,000 tons.

Under the scheme the gas, made at the oil refinery on the Isle of Grain, would be fed into the Board's gas grid system near Strood. This grid system, which is being rapidly developed, will cover an area of some 1750 square miles and will serve South London and extend to Guildford, Horsham, Maidstone and Rochester.

It is estimated that production of gas from oil on the Isle of Grain, if the scheme goes forward to the maximum scale contemplated, would save the country some 700,000 tons of coal a year.

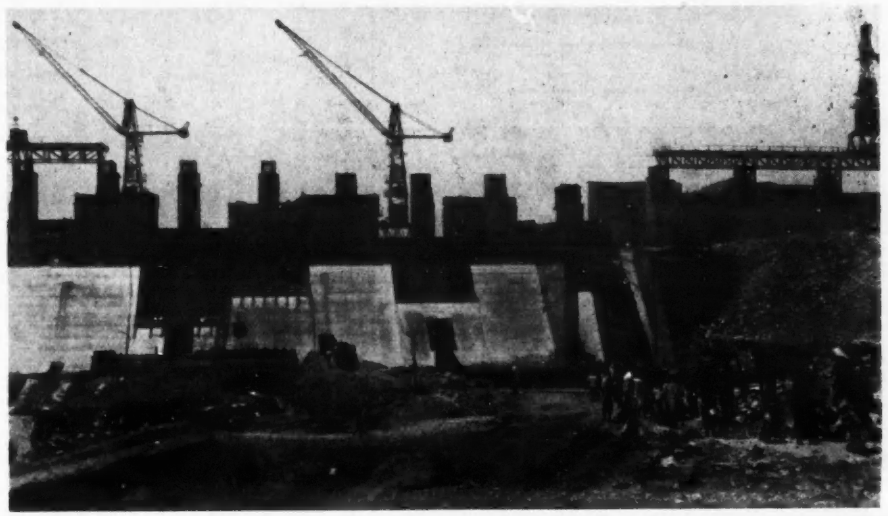
The Segas process for making gas from oil was discovered in the Central Laboratories of the South Eastern Gas Board at Old Kent Road. A prototype installation designed jointly with the Power Gas Corporation, Ltd., which became licensees for the plant, was described in THE ENGINEER of January 1, 1954. It was erected at Sydenham, where it is producing 800,000 cubic feet a day of gas of a standard quality.

WATER CONSERVATION SCHEMES IN INDIA AND PAKISTAN

Kotri barrage on the Indus River in Sind, Pakistan

The head regulator of the Nangal-Hydel canal of the Bhakra-Nangal project in Punjab

Tungabhadra dam from the Madras side of the project, in March, 1954



Konar dam, an element of the Damodar Valley development

Some Commonwealth and Foreign Civil Engineering Schemes

No. III—(*Concluded from page 372, March 18th*)

A brief review of some civil engineering developments in overseas countries and of their progress during 1954 is given here. The article is complementary to "Civil Engineering in 1954," published in January, in which works carried out by British civil engineers in 1954 were reviewed.

CIVIL engineering activities in the Netherlands were of much topical interest to British engineers in 1954. Damage from the disastrous floods of 1953 was being finally repaired, after great expenditure of money and effort, and last June, the Institution of Mechanical Engineers held its summer meeting at The Hague, and members were able to visit many Dutch engineering works. On June 11, 1954, THE ENGINEER published a supplement to mark the occasion of the summer meeting, in which detailed accounts were given of recent Dutch sea defence works, and of the construction of the Velsen tunnel and the Amsterdam-Utrecht motorway. Some details were also given in the supplement, and in our issue of July 2nd last, of the progress of reclamation in the Ijsselmeer and of the "Delta" committee's ambitious proposals for flood protection in South-Western Holland. Thus the civil engineering works we described during 1954 would by themselves be a commendable year's achievement for a country of the size of the Netherlands, but even so, they formed only a part of the work in progress, and we are able to give here some details of two further works of considerable technical interest, to represent Dutch civil engineering in 1954.

The accompanying illustration shows the progress made by last August in the construction of a dry dock which is being built for the Netherland Dock and Shipbuilding Company at Amsterdam. The dock is 800ft long and 130ft wide (120ft wide at the entrance), with a depth of water of 26ft 6in over the sill, the harbour here being non-tidal, as it is controlled by the Ymuiden locks.

Excavation was done by dredging, which was commenced in May, 1953. This method of wet excavation was chosen because transport by road or rail was too expensive and difficult. The excavated area was separated from the harbour by an earth cofferdam protected on its outer side by light steel sheet piling, and forty-eight borehole pumps were placed in position to keep the site dry during construction. The site was drained by two pumps placed on a raft, assisted by the borehole pumps. The water level was lowered not more than 8in per twenty-four hours to prevent collapse of the slopes.

The dock consists of a reinforced concrete invert and walls. Contraction joints are placed 189ft apart in the invert and 63ft apart in the walls. In the pump room near the dock head there are six electrically driven pumps, each with a capacity of 20,000 cubic yards per hour. They are able to drain the dock in one hour. The dock is to be filled, in less than one hour, by two cylinder gates, each serving a 7ft 7½in diameter culvert, one in each side of the dockhead. The shape of the culverts and sumps was determined after model tests carried out by the hydraulical research laboratory at Delft. The dock is closed by a Box gate.

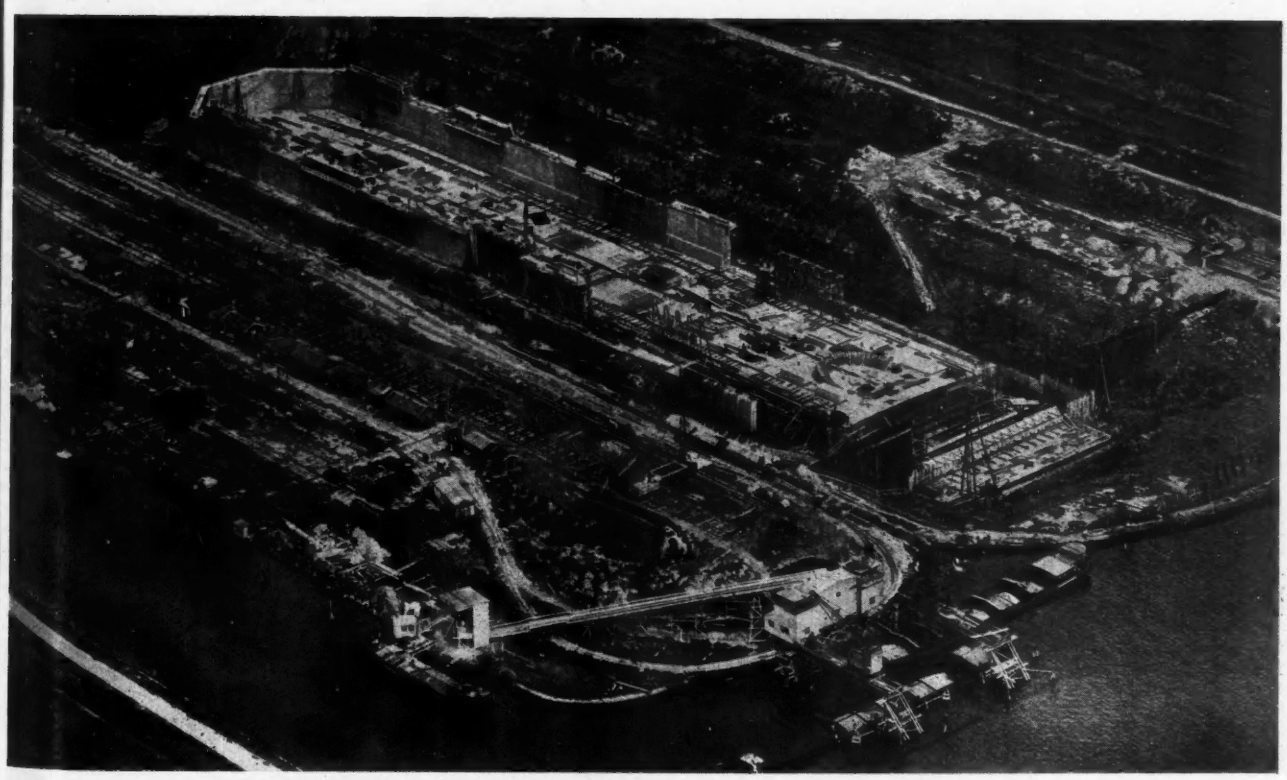
The concrete, totalling 100,000 cubic yards, contains 500 lb of blast furnace slag cement, 1120 lb of sand and 2250 lb of gravel per cubic yard. Sand and gravel are supplied by barges of about 800 tons and discharged by two electrically driven cranes into weighing hoppers above the mixers. The cement comes in bulk in ships of about 400 tons from a cement works situated at a distance of 15 miles along the North Sea Canal. The cement is discharged by a grab crane on a conveyor belt and brought up over a distance of 200ft to the mixing station. There is no stock of cement, sand and gravel on the job; the sailing schedule of the ships is timed accurately to the progress of the work. The concrete is mixed in two mixers and transported by diesel traction over narrow gauge to two 3-ton cable cranes. The concrete is worked stiff—the w/c ratio is 0·45—and is compacted by electric vibrators. The wooden moulds are handled with 3-ton electric cranes, travelling on tracks in the dock. The difficulty of attracting enough skilled labour made the contractors divide all the reinforcing mats of the walls into units of 3 tons weight. These were laid out on the dock bottom, fastened on one of each five crossings by welding, and erected by the 3-ton cranes. This system, it was found, accelerated progress, but was an extra burden for the drawing-office. All the reinforcing steel, in diameter up to 2in, supplied by the rolling mill in bars of 46ft, was run through an electric butt welding machine and afterwards cut at the required length with a maximum of 82ft. The last concrete was expected to be in place at the end of January. Then the space behind the dock walls was to be filled with sand by hydraulic filling. The layout of plant, as described above, can be clearly seen in our illustration. This interesting work was built by the contracting firm Hollandsche Beton Maatschappij N.V.

Another Dutch work in progress in 1954 was the construction of a bridge, 1000m in length, at Moerdijk, on the main Antwerp/Amsterdam railway line. This bridge is a double-line structure, replacing an eighty-year-old single-line bridge and using the same piers as its predecessor. The new superstructure consists of five 208m span and one 30m span steel arches. The arches are being first assembled, three of them on a scaffold close to the bridge site, and two at a fabricating works at Dordrecht, and then half-arches of 104m length are floated into position on successive periods of possession of the line. Two complete arches were positioned last summer and the work is to be finished this year.

Water Conservation Schemes in India and Pakistan

As examples of civil engineering activity in the Colombo plan countries, we give brief details of some irrigation and water power schemes in India and Pakistan.

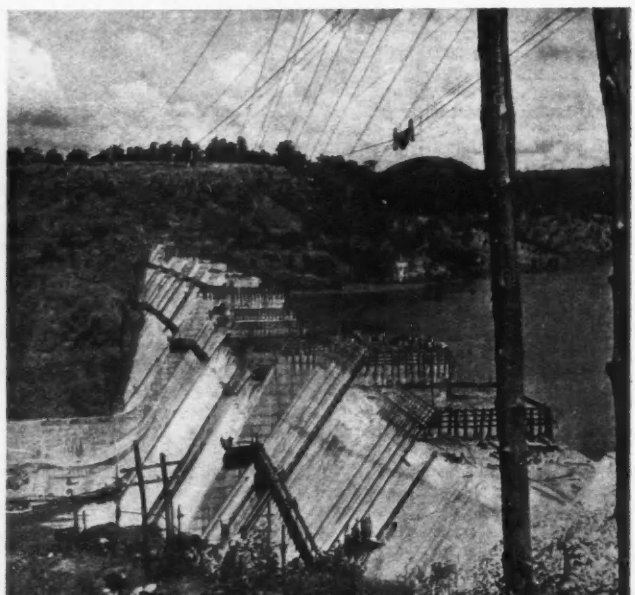
Irrigation problems in the western and eastern parts of Pakistan are very different in their nature, but their solution is of great importance, since agriculture is the mainstay of the country's future prosperity. West Pakistan, is, generally speaking, an arid zone, and the shortage of water is one of the main problems. Moreover, the



Dry dock under construction at Amsterdam, showing progress in August, 1954

small amount of rainfall is unevenly distributed throughout the year, and in some places irrigation is rendered more difficult by ground water salinity and water-logged areas. In East Pakistan practically the whole of the 60in to 80in of rainfall occurs during five months, in the monsoon period. Two major irrigation projects—the Ganges-Kobadak and Teesta barrage projects—are in hand in East Pakistan. In West Pakistan, many irrigation works which were built during the British administration already exist and there is an elaborate system of canal irrigation, such that 1 acre out of 4 is under cultivation. But the existing works are inadequate, and the construction of new canals, the exploitation of underground water, and the building of new irrigation projects are being undertaken as a basis for the development of agriculture and soil erosion is being studied.

The irrigation project with which we exemplify West Pakistan's progress in 1954 is the Kotri barrage on the Indus River in Lower Sind. It was opened on March 15th by the Governor General, Mr. Ghulam Mohammed. The Indus is well known to engineers for the famous Lloyd barrage at Sukkur, described in our columns in January, 1932, when it was inaugurated, as "the largest irrigation system in the world and the greatest contribution to irrigation made by British engineers." The Lloyd barrage is nearly a mile long, with sixty-six 60ft spans with sluice gates, and with canal intakes and regulators on each bank, the total cultivable area being about 5,000,000 acres. The Kotri barrage, which is about 200 miles downstream from Sukkur, is similar in many respects to the earlier scheme, and although smaller, is on a vast scale. Constructional work was started in 1948, and the barrage consists of forty-four spans, each of 60ft. The scheme involves three feeder canals, two on the left bank and one on the right. It is intended that the scheme should supplement areas already under cultivation, so that they receive adequate supplies of water, and increase the area under cultivation by 2,800,000 acres ; it is expected that 600,000 acres will be under crops by 1956–57. The sluice gates, lock gates and lift bridge have been supplied and erected by Ransomes and Rapier, Ltd., the firm which made the gates of the Lloyd barrage. The bridge which spans the barrage is a prestressed concrete structure consisting of forty-three spans of 67ft each, giving a total length of 2881ft ; it was built by the British firm of Gammon Pakistan, Ltd.



Vaitarna dam, for the water supply of Bombay

The Bhakra-Nangal Scheme

A major left-bank tributary of the Indus—the Sutlej—is also being developed for irrigation and power in Indian territory. The Bhakra-Nangal project, as this development is called, has already been described in these columns (THE ENGINEER, August 10, 1951), but is mentioned here because the Bhakra canal system was opened on July 8th last by the Indian Prime Minister, Mr. Nehru. It has been reported that there has been some controversy about the scheme: for Pakistani opinion held that India would abstract more water from the river, before it reached the Pakistan frontier, than was just. The importance of maintaining the flow of the Indus in Pakistan will be very evident from the description just given of the irrigation systems which it supplies, and as several of the main sources of the river are in Indian territory, the cause of the concern can be readily appreciated. As far as the Bhakra-Nangal scheme is concerned, however, the Indian viewpoint is that only the monsoon surplus, which would otherwise be wasted, will be used in the Nangal canal system, so the supply to Pakistan will not be reduced (apparently no schemes for storage of the monsoon floods in Pakistan's territory have been put forward). Furthermore, it is pointed out that efficient regulation of rivers such as the Sutlej, by storage, might increase the useful flow available to Pakistan. From the figures given in our earlier article it would appear that the Indian contention, i.e. that only the "surplus" monsoon water will be used for irrigation—would be factually correct when the Bhakra storage reservoir is in operation. This reservoir, which is to be formed by a gravity dam 680ft in height, will have a useful storage capacity of 5,700,000 acre-feet. The annual consumption of the irrigation system is apparently between 8,000,000 and 9,000,000 acre-feet, and the average annual flow of the river is 13,500,000 acre-feet, varying from an estimated peak flood of nearly 400,000 cusecs to a minimum of 3000 cusecs.

On page 406 we illustrate the head regulator of the main intake—the Nangal-Hydel canal—supplying the irrigation system of the scheme, with the Nangal barrage shown on the left. The main canal is about 40 miles in length, and two 72MW power stations are included along its length. The total area which the scheme will irrigate is estimated at 6,500,000 acres—larger than the area served by the Lloyd barrage.

Two power stations are planned at the site of the main dam, with a total installed capacity of about 1000MW and a firm power output of 400MW. The two 50ft diversion tunnels at the dam site were, we understand, approaching completion last year. Irrigation was started and the two power stations on the canal were expected to be completed. The whole project (its estimated cost is nearly £100 million) is due for completion in 1958–59.

Damodar Valley Projects

The Damodar Valley scheme is another Indian venture which has received no little publicity, as it is a comprehensive development, modelled on the Tennessee Valley Authority's well-known works. The conception of this scheme, as with most of the other major projects of recent years on the Indian sub-continent, dates from the time of the British administration.

The project envisages land reclamation, irrigation, soil conservation, forest conservation, resettlement, and industrial development, with the control of the waters of the River Damodar and its tributaries as its mainstay. In the first phase of development, scheduled for completion by 1955–56, the main works are four dams at Tilaiya and Maithon across the Barakar, at Panchet Hill on the Damodar, and across the Konar. The reservoirs so formed will have an aggregate storage capacity of 2,440,000 acre-feet. Power will be generated at all the four dams with an installed capacity of about 124MW. In addition, a thermal plant has been built at Bokaro, with an ultimate capacity of 200MW. The regulated flow below the dams will be picked up at Durgapur, where a barrage is to be constructed for diverting the flow into a network of canals designed to irrigate over 1,000,000 acres of kharif* and 300,000 acres of rabi† crops in West Bengal. A part of this canal system will be utilised for navigation also, providing an all-water route between the Raniganj coalfields and Calcutta.

Construction of the Konar dam reached a fairly advanced stage in 1954 ; the illustration of the dam on page 406 is reproduced from a progress photograph taken early in the year. Steel crane gantries for the tower cranes may be observed at two levels, and it appears that the steel towers are built into the concrete of the dam.

Tungabhadra and Vaitarna Dams

The Tungabhadra dam, also illustrated on page 406, is a joint enterprise of Madras and Hyderabad States. It is a 160ft high dam, nearly 8000ft in length, across the Tungabhadra River. One 225-mile main canal leading from the right bank will irrigate about 250,000 acres in Madras, and a 127-mile canal on the left about 450,000 acres in Hyderabad. At the dam site and at the falls along the canals hydro-electric capacity of 60MW will be installed on the Madras side and of 110MW on the Hyderabad side. The work on the dam was almost finished last year, considerable progress was made with the canals, and the Hagari aqueduct, a main cross drainage work on the right bank canal was built. On July 1, 1953, water for irrigation began to flow from both sides of the reservoir benefiting 30,000 acres of land in Madras and 6000 acres in Hyderabad.

Our last illustration shows the Vaitarna dam, a structure built for the water supply of Bombay (see THE ENGINEER, November 1 and 7, 1952, and February 20, 1953),; the Vaitarna and Tansa scheme was inaugurated by the Prime Minister of India on October 6, 1954. The dam is 269ft high and has a crest length of 1820ft ; it is a gravity structure. Its construction is of interest because of the cooling system for the aggregates. At the dam the air temperature varies from 114 deg. to 52 deg. Fah. and the water temperature is 85 deg. Fah. The final stable temperature of the dam is estimated at 85 deg. to 90 deg. Fah. The temperature rise due to the hydration of cement has been calculated as being about 50 deg. Fah. above the pouring temperature after about fifty-two hours. The normal temperatures of the components of the mix are about 100 deg. Fah. With no cooling the interior heat of the concrete would increase to about 150 deg. Fah.: to keep the maximum heat to within 25 deg. Fah. of the ultimate stable temperature the concrete is cooled to 57 deg. Fah. at mixing and 60 deg. Fah. when poured.

After crushing and screening, the aggregates are conveyed on six slow-moving belt conveyors through a cooling tunnel, which is 330ft long and cork insulated. In conjunction with this there is a Freon cooling plant having a refrigeration capacity of 650 tons. During transit through the tunnel the coarse aggregates are cooled to about 40 deg. Fah. by chilled water sprays and inundation, and afterwards passed through a high-velocity blast of moisture-free air chilled to between 40 deg. and 42 deg. Fah. The fine grades are cooled by the chilled air only, the temperature being reduced to 72 deg. Fah. The mixing water is chilled to 36 deg. Fah. by the same cooling plant. The cement is not cooled before mixing. The chilled air is circulated by eight "Aerofoil" fans, manufactured by Woods of Colchester, Ltd., each delivering 27,500 cubic feet per minute.

* Kharif crops are the monsoon crops (May to September).
† Rabi crops are those grown in the cold weather (October to April).

Conversion of Inch and Metric Sizes on Engineering Drawings*

By L. W. NICKOLS, B.Sc. (Eng.), M.I.Mech.E., A.M.I.Prod.E.†

Consideration is given to the influence of factors such as accuracy of measurement, the difference in size between the original and converted size, and the method of rounding the converted size. Finally, a recommended scheme for conversion is laid down which is logical and simple.

SINCE the end of the war the conversion of inch and metric sizes on engineering drawings has become of considerable importance in trade with foreign countries using the metric system. Some British firms have established manufacturing or assembly plants in these countries because of import limitations or for servicing purposes, and consequently it has been desirable to redimension inch system engineering drawings in millimetres. On the other hand, foreign firms may find it necessary to redimension metric system drawings in inches for use in this country. For defence purposes, also, it may be desirable for British designs of weapons or aircraft engines to be manufactured in countries using the metric system, and conversely. The difficulty encountered in the conversion of these drawings arises when it is necessary to formulate a procedure for conversion which ensures that components acceptable when inspected to a drawing dimensioned in one set of units are not rejected when inspected to the corresponding drawing dimensioned in the other set of units.

Such dimensional interchangeability can, of course, be maintained by making the conversion to a very high degree of accuracy, i.e. by calculating the converted size to a large number of decimal places, but there is little justification in the use of a number of decimal places not warranted by the available data, and too many decimal places in the converted size become an embarrassment in practical use.

In laying down a recommended procedure for conversion, using a recognised conversion factor as a basis, the problem is to obtain a suitable degree of precision in the converted value. Various factors have to be considered when deciding the optimum fineness of rounding the converted value. One of the most important is the inevitable inaccuracy of measurement always associated with any measured size. Because of this, a limit specified on an engineering drawing is not in practice a rigid line of demarcation, but is the mid-point of an ill-defined zone within which the true size falls when the measured size is the same as the specified limit. It is necessary also to decide how far the converted and rounded value may depart from the original size, bearing in mind the effect of any such departure on the manufacturing tolerance or the allowance between the mating features. Finally, the best method of rounding the converted limit has to be decided, whether to round between or outside the original limits or to the nearest multiple of the fineness of rounding.

All these factors are considered in the following paragraphs and, in conclusion, a recommended scheme for conversion is laid down which is logical and simple.

Conversion Factor

The conversion factor used is the simple relation 1in=25·4mm. This factor has legal sanction for use in trade in Great Britain and is the basis for the conversion of all linear measurements given in the Standards of the British Standards Institution. It is accurate to within two parts in a million, and this order of accuracy permits conversions to be made with errors which are negligible for ordinary engineering purposes.

The Effect of Inaccuracies of Measurement on the Interpretation of Sizes

Any recommended procedure for the conversion of sizes from one system of units to another is necessarily dependent on the interpretation in practice of these sizes.

If a theoretical size obtained by calculation is quoted to a certain number of decimal places it would be reasonable to assume, in the absence of other information such as a tolerance, that the actual size is required to conform with the theoretical size to within $\pm\frac{1}{2}$ of the unit in the last decimal place. This interpretation of a specified size cannot be applied to the sizes of features required to be universally interchangeable. The specified limits of size of such features are regarded in theory as being absolutely rigid without regard to the number of decimal places to which the limits are specified. For example, a limit may be stated on the drawing in the alternative forms ·750in and ·7500in, but both these methods of statement mean that in theory the size of the limit is ·7500in exactly.

In practice, however, it is only possible to conform to the specified limits to within the accuracy of the method of dimensional inspection adopted, whether by limit gauging or by direct measurement, the latter being generally the more accurate method. The theoretically rigid limit on the drawing becomes in practice an ill-defined zone, the mid-point of which is defined by the drawing limit. When the measured size is the same as the drawing limit, the true size may lie anywhere within a zone of width $2x$ disposed symmetrically about the drawing limit, where $\pm x$ is the accuracy of the method of measurement. It should be emphasised at this stage that the accuracy of direct measurement is not entirely dependent on the basic accuracy of the measuring instrument employed, but is affected to a considerable extent by such factors as the nominal size, the quality of surface finish and the errors of geometric form of the feature being measured. It is reasonable to assume that the highest practicable accuracy of measurement is closely related to the tolerance on the feature, as the tolerance controls the surface finish, and errors of geometric form, and is itself dependent on the nominal size of the feature.

The question then arises as to what is the attainable accuracy of measurement of an engineering component. Adams‡ has suggested that this accuracy of measurement is of the order of ±2 to ±4 per cent of the component tolerance. This suggestion appears reasonable for components having tolerances of values down to 0·001in (0·025mm), at which value it corresponds to an accuracy of measurement of $\pm0{\cdot}000\ 02$in to $\pm0{\cdot}000\ 04$in ($\pm0{\cdot}5\mu$ to $\pm1\mu$), providing that the surface finish and geometric form of the components are satisfactory. It is doubtful, however, whether a higher precision of measurement than about $\pm0{\cdot}000\ 03$in ($\pm0{\cdot}75\mu$) is attainable with present-day measuring equipment of the types encountered in engineering inspection departments, and this precision of measurement will, of course, amount to a progressively increasing proportion of the component tolerance as the latter is reduced below 0·001in. Thus, for a component tolerance of 0·0003in ($7{\cdot}5\mu$), it is equivalent to ±10 per cent of the component tolerance.

Summing up, in practice it is only possible to conform to specified limits of size to within the accuracy of the method of inspection used, and this accuracy is unlikely to be better than about ±2 to ±4 per cent of the feature tolerance if the latter is 0·001in or greater. For feature tolerances less than 0·001in the accuracy of measurement is unlikely to be better than $\pm0{\cdot}000\ 03$in.

Effect of Differences in Size Between Original and Converted Limits

Before formulating a scheme for converting limits to a suitable degree of precision, it will be well to consider the effect of a difference in size between the original limit and the rounded converted limit.

For this purpose, the original limit and the rounded converted limit are regarded as rigid, i.e. no account is taken of any practical variation in the limits due to the unavoidable inaccuracies of the method of dimensional inspection adopted.

It may be argued that a small fineness of rounding of the converted limit, so that its size agrees closely with the original limit, is not essential. The reason advanced in favour of this argument is that if the manufacturing process is under satisfactory control, then the size distribution curve of the component approximates to a Normal (Gaussian) curve, and the converted limits can differ appreciably from the original limits without affecting to any noticeable extent the percentages of components accepted or rejected. This is illustrated in Fig. 1 ; the curve (1) representing the Normal Curve of components made so as to take full advantage of the tolerance *AG*. The shaded areas *ABC* and *EFG* indicate the additional number of components rejected when the converted limits are inside the original limits and differ from them by relatively large amounts *AB* and *EG*, which are in this case equal to one sixth of the tolerance ; the additional numbers of rejected components represented by each of the areas *ABC* and *EFG* are equivalent to only $2\frac{1}{2}$ per cent of the total number of components.

The above argument is not always correct for the following reasons. In the first place the tolerance is in most cases determined from functioning considerations, and should be as large as possible in order to render manufacture as easy as possible. A Normal or size distribution curve applies to the individual manufacturing process used, and the " spread " of that curve is dependent on that process and may have no relation to the drawing tolerance, provided, of course, that it is smaller than the latter. It is quite permissible, although not desirable perhaps, for the manufacturing process to have the size distribution curve (2) which is not symmetrically placed within the tolerance zone *AG*. In this particular case, if the difference in size *AB* between the original and

* Communication from the National Physical Laboratory.
† Principal Scientific Officer, Metrology Division, National Physical Laboratory.

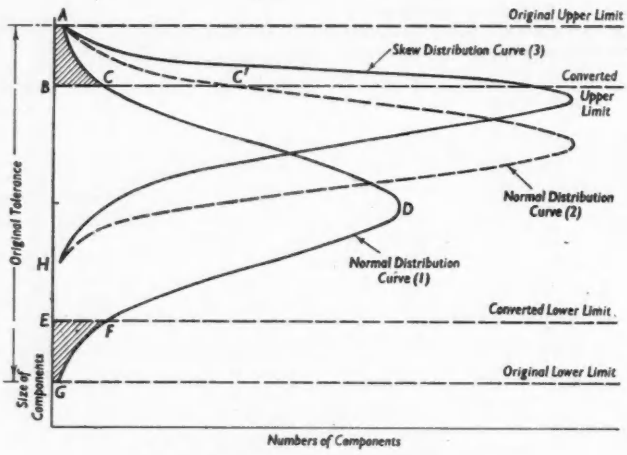
‡ " Principles and Practice Governing Interchangeability and the Specification of Manufacturing Limits of Size, as Influenced by Statistical Considerations," G. C. Adams, *Proc. I.Mech.E.* (A), 1953, 167, 2.

converted limits is equal to, say, one-sixth of the component tolerance, then the percentage of components acceptable to the original limit and rejected to the converted limit, indicated by the area *ABC'*, will be about 7 per cent, which is rather large.

If the size distribution curve covering the range of size *AH* is a skew curve, as may occur in practice, then the percentage of components acceptable to the original limit *A* and rejected to the converted limit *B* may far exceed 7 per cent ; this is shown by curve (3).

A further disadvantage arising from the particular example given, in which the converted limits fall well between the original limits, is that in the conversion the manufacturing tolerance is reduced appreciably. The larger the difference between the original and converted limits the greater will be the reduction in the tolerance.

If the converted and rounded limit falls outside the original limits, then if the converted limit is the maximum metal limit of one of a pair of mating features, the allowance or minimum clearance between the features is reduced. If the difference between the original and converted limits is appreciable, this reduction in the allowance may be sufficiently large to affect adversely the assembly and functioning of the mating features.



Area ABC represents 2½ per cent of components.
Area ABC' represents 7 per cent of components.

Effect of precision of conversion on number of components rejected when inspected to converted limits

Quite apart from the above considerations any recommended procedure for conversion must be applicable to manufacture as a whole. It must not be applicable only to conditions of adequate manufacturing and statistical control. It must be suitable also for conditions, which it is hoped will be occasional but must not be neglected, in which the proportion of components made to sizes near the limit is large.

From all aspects, therefore, it is very desirable for the converted limit to conform closely with the original limit.

Fineness and Direction of Rounding Converted Limits

A small fineness of rounding the converted limit is desirable if the effects described above of the differences in size between the original and converted limits are to be reduced to a minimum.

There are three alternative procedures which can be followed in rounding the converted limit. The first is to round to the nearest multiple of the fineness of rounding irrespective of whether the converted and rounded limit falls between or outside the original limits. The second and third procedures respectively, are to round the converted limits always between or always outside the original limits. If the fineness of rounding is denoted by "*y*," then if the first procedure is adopted the rounded values will be within "$\frac{1}{2}y$" of the original limits. If the second or third procedures are adopted, the rounded values may differ from the original limits by amounts up to "*y*."

The first procedure is to be preferred, as, for a given fineness of rounding, the maximum difference between the original and converted limits is only one-half of that resulting from the use of the other two procedures. Another advantage of the first procedure is that, in the mean, the tolerance between the converted limits is the same as that between the original limits and the allowance remains unchanged.

Theoretical Basis for Recommended Procedure for Conversion

It has been indicated earlier that in practice it is only possible to conform to specified limits of size to within the accuracy of the method of dimensional inspection used, and this accuracy is unlikely to be better than about ±2 to ±4 per cent of the component tolerance for tolerances of 0·001in or greater. Also, it is desirable that any difference between the original and converted limits to be kept to a minimum, and that the converted limits be rounded in the most suitable manner.

The theoretical basis of the recommended procedure for converting limits is that if the converted limits are rounded to an accuracy better than that to which it is possible to control the original limits in practice, then effective dimensional interchangeability of components made respectively to the original and to the converted limits is secured, and no inspection discrepancies or functional troubles are likely to arise. For work having tolerances of about 0·001in or greater this is accomplished by rounding the converted size to the nearest 5 per cent of the component tolerance ; the maximum difference in size between the original and converted limits will then be not more than 2½ per cent. For work having tolerances of less than 0·001in, even if the surface finish and geometric form are good, the accuracy of measurement commonly attainable in the engineering industry is probably not better than ±0·000 05in and it is reasonable to assume that an accuracy of ±0·000 03in is the best that could be realised in regular production. There is little point, therefore, in rounding the converted sizes to a fineness better than the nearest 0·000 05in or 0·001mm, as appropriate, resulting in a maximum error of conversion of 0·000 025in or 0·0005mm, respectively.

In the proposed scheme the tolerances have been grouped in order to obtain a reasonably simplified procedure ; to this extent it has been necessary to depart from the theoretical basis adopted, but the grouping has been so arranged that no additional loss of accuracy is introduced. The recommended fineness of rounding the converted limit for each group of tolerances is given in Tables I and II, and in these Tables the maximum error in the conversion expressed as a percentage of the tolerance is given in column 4.

Recommended Procedure for the Conversion of Inch and Metric Limits and Tolerances

The case of a simple feature, such as a shaft or a hole, is dealt with first, and the recommended procedure is then applied to the more difficult case of a group of simple features which have to conform to a definite positional relationship with each other, e.g. the bolt-holes in a flange are simple features having sizes which must lie between specified limits and, in addition, the position of each hole with relation to the others in the group is specified.

The recommended procedure has been made as straightforward as possible by giving it in the form of a number of rules, which are arranged in a logical sequence so that by following them no difficulty should arise in converting limits and tolerances from inch units into their metric equivalents and vice versa. Examples are also given showing the application in practice of the conversion rules.

Before giving the procedure in detail it is useful to recall the different ways in which limiting dimensions of interchangeable features are shown in engineering drawings. Examples of these different ways are given below:—

$\cdot 999_{\cdot 995}$; $\cdot 999 - \cdot 004$; $\cdot 995 + \cdot 004$; $\cdot 997 \pm \cdot 002$; $1 \cdot 000^{-\cdot 001}_{-\cdot 005}$; $\cdot 999^{+0}_{-\cdot 004}$; $\cdot 995^{+\cdot 004}_{-0}$.

All these have precisely the same meaning and show that the tolerance is ·004 and the

Table I—*Conversion of Inch Limits of Size to Millimetre Limits of Size*

1	2	3	4
Tolerance on original inch limit		Fineness of rounding. Derived millimetre limits to be rounded to the nearest	Maximum error in conversion, expressed as percentage of Cols. 1 and 2
From	Up to, but not including		
Inch	Inch	Millimetre	Per cent
0·0004	0·0008	0·001	5 to 2·5
0·0008	0·008		2·5 to 0·25
0·008	0·08	0·01	Ditto
0·08	0·8	0·1	Ditto

Table II—*Conversion of Millimetre Limits of Size to Inch Limits of Size*

1	2	3	4
Tolerance on original millimetre limit		Fineness of rounding. Derived inch limits to be rounded to the nearest	Maximum error in conversion expressed as percentage of Cols. 1 and 2
From	Up to, but not including		
Millimetre	Millimetre	Inch	Per cent
0·01	0·05	0·000 05	6·25 to 1·25
0·05	0·5	0·0001	2·5 to 0·25
0·5	5	0·001	Ditto
5	50	0·01	Ditto

limits of size are ·999 and ·995, though the last three are not recommended in B.S.308 : 1903, "Engineering Drawing Practice."

Case 1 : Simple Features

Rule 1.—From the tolerance on the feature, by means of Table I or Table II, determine the fineness of rounding the converted value and accordingly the number of decimal places to be retained therein.

When the tolerance is not given directly on the drawing it should be derived by subtracting the minimum limit of size from the maximum limit of size.

Rule 2.—Convert the two limits of size in one system of units into the equivalent limits of size in the other system of units to two more decimal places than the number of decimal places to be retained in the final rounded value, using the conversion factor 1in=25·4mm.

If the two limits of size are not directly stated on the drawing they should be derived. Thus, for a dimension stated as ·999–·003, the limits of size are ·999 and ·996.

Rule 3.—Round the converted limits of size obtained by Rule 2 to the fineness determined from Rule 1, so that the rounded value is nearest the unrounded value.

(1) It is unimportant whether the rounded value falls inside or outside the unrounded converted limits.

(2) If the unrounded value determined from Rule 2 falls exactly midway between the two adjacent rounded values, choose the even rounded value. For example, if the unrounded value is 12·012 50 and the fineness of rounding is 0·001, then the rounded value is 12·012. If the unrounded value is 12·013 50 then the rounded value is 12·014. The same rule applies if the fineness of rounding is 0·000 05. If, for example, the unrounded value is 1·091 525 0 then the rounded value is 1·091 50. If the unrounded value is 1·091 575 0 then the rounded value is 1·091 60.

Example 1 : *Conversion Into Millimetres of a Toleranced Dimension* 0·0703+0·0009*in*.—The limits of size in inches are 0·0703 and 0·0712.

By Rule 1 the recommended fineness of rounding obtained from column 3 of Table I for a tolerance of 0·0009in is 0·001mm.

By Rule 2 the limits of size in millimetres to five decimal places, i.e. two decimal places beyond the three decimal places to which the fineness of rounding is given, are :—

$$0{\cdot}0703\times25{\cdot}4=1{\cdot}785\ 62\text{mm}$$
$$0{\cdot}0712\times25{\cdot}4=1{\cdot}808\ 48\text{mm}.$$

By Rule 3 the millimetre limits of size are rounded to the nearest 0·001mm, giving the values 1·786mm and 1·808mm.

The millimetre limits of size calculated above may be stated on the drawing by either of the two forms of drawing statement recommended in B.S. 308 : 1953 for unilaterally toleranced dimensions, namely :—

$$\begin{matrix}1{\cdot}786\\1{\cdot}808\end{matrix}\ \text{or}\ 1{\cdot}786+{\cdot}022\text{mm}$$

Example 2 : *Conversion Into Inches of a Toleranced Dimension* 25·000+0·030*mm*.—The limits of size in millimetres are 25·000 and 25·030. By Rule 1, the recommended fineness of rounding obtained from column 3 of Table II for a tolerance of 0·030mm is 0·000 05in.

By Rule 2 the limits of size in inches to seven decimal places, i.e. two decimal places beyond the five decimal places to which the fineness of rounding is given, are :

$$25{\cdot}000\div25{\cdot}4=0{\cdot}984\ 252\ 0\text{in}$$
$$25{\cdot}030\div25{\cdot}4=0{\cdot}985\ 433\ 1\text{in}$$

By Rule 3, the inch limits of size are rounded to the nearest 0·000 05in, giving the values 0·984 25in and 0·985 45in.

The inch limits of size calculated above may be stated on the drawing in either of the following ways :—

$$\begin{matrix}{\cdot}984\ 25\\{\cdot}985\ 45\end{matrix}\ \text{or}\ {\cdot}984\ 25+{\cdot}0012\text{in}$$

Example 3 : *Conversion Into Inches of a Toleranced Dimension* 57·000+0·050*mm*.—The limits of size in millimetres are 57·000 and 57·050.

By Rule 1, the recommended fineness of rounding obtained from column 3 of Table II for a tolerance of 0·050mm is 0·0001in.

By Rule 2, the limits of size in inches to six decimal places, i.e. two decimal places beyond the four decimal places to which the fineness of rounding is given, are :

$$57{\cdot}000\div25{\cdot}4=2{\cdot}244\ 094\text{in}$$
$$57{\cdot}050\div25{\cdot}4=2{\cdot}246\ 063\text{in}.$$

By Rule 3, the inch limits of size are rounded to the nearest 0·0001in, giving the values 2·2441in and 2·2461in.

The inch limits of size calculated above may be stated on the drawing in either of the following ways :—

$$\begin{matrix}2{\cdot}2441\\2{\cdot}2461\end{matrix}\ \text{or}\ 2{\cdot}2441+{\cdot}0020\text{in}$$

Case 2 : Groups of Simple Positional Features

Each group consists of a number of simple features, such as holes or pins, the sizes of which are toleranced in the normal way. These sizes are converted as described in Case 1. In addition, the relative positions of the simple features with respect to each other are toleranced. This may be done in either of two ways, i.e. by tolerancing the centre distances defining the true positions of the features, or by applying a "geometrical" positional tolerance to the true positions of the features. A "geometrical" tolerance is defined as "the maximum permissible overall variation of form or position about that shown on the drawing." In other words, it is the width or diameter of a tolerance zone within which the surface, or the middle plane or axis of the feature, is to lie."§

(a) *Positional Features Having Toleranced Centre Distances*.—The toleranced centre distance is converted in the same way as the limits of size of a feature, using Rules 1, 2 and 3, and Tables I or II.

(b) *Positional Features Having Geometrical Positional Tolerances*.—Rule 4 : From the geometrical tolerance on the position of the feature, by means of Tables I or II, determine the fineness of rounding the converted positional dimensions and accordingly the number of decimal places to be retained therein.

Rule 5 : Convert the geometrical tolerances and the constructional dimensions defining the true positions of the features to two more decimal places than the number of decimal places to be retained in the final rounded value, using the conversion factor 1in=25·4mm.

Rule 6 : Round the converted geometrical tolerances and constructional dimensions obtained by Rule 5 to the fineness determined from Rule 4 so that the rounded value is nearest the unrounded value. See notes (1) and (2) to Rule 3.

Example.—

1·508 IN. (TP)
POSN TOL ·005 IN DIA.

The above method of dimensioning, recommended in B.S. 308 : 1953, means that the true position of a certain feature is located by a dimension 1·508in and the centre line of the feature is allowed to depart from that true position providing it falls within a 0·005in diameter circle.

By Rule 4, the recommended fineness of rounding obtained from column 3 of Table I for a tolerance of 0·005in is 0·001mm.

By Rule 5, the converted sizes in millimetres to five decimal places of the 1·508in dimension and the 0·005in tolerance, i.e. two decimal places beyond the three decimal places to which the fineness of rounding is given, are :

$$1{\cdot}508\times25{\cdot}4=38{\cdot}303\ 20\text{mm}$$
$$0{\cdot}005\times25{\cdot}4=0{\cdot}127\ 00\text{mm}.$$

By Rule 6, the converted sizes are rounded to the nearest 0·001mm giving the values 38·303mm for the 1·508in dimension and 0·127mm for the 0·005in geometrical tolerance.

Untoleranced General Dimensions

These dimensions are usually unimportant and it is only necessary to round the converted values with discretion.

The recommended conversion scheme has been formulated in conjunction with the late Mr. J. E. Sears, C.B.E., M.A., M.I.Mech.E., and it was the intention that he should have been a joint author of this paper.

The work described above was carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

§ B.S. 308 : 1953, "Engineering Drawing Practice."

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1

TUBULAR BOX SPANNERS

No. 2558 : 1954. Price 4s. The publication of this Standard follows that of a few months ago of B.S. 192 for open-ended spanners. Owing to the wide and varied uses of this type of spanner, with its long history (and with early memories of spanners knocked up from piping) this standard will be widely welcomed by those who face the sometimes irritating problem of getting at nuts in awkward and restricted corners. The range of hexagons catered for in this specification is the same as that dealt with by its immediate predecessor and includes all the unified sizes, B.A., metric, black hexagons and Whitworth large hexagons. The needs of all users are therefore met. The quality of the spanners is denoted by two grades, A and B. Grade A is the superior quality. The apparent anomaly that the accuracies of the B grade are more exact than those of the A grade is explained by the fact that Grade A spanners are heat-treated and allowance has therefore to be made for any resulting distortion. The torque test is an invaluable addition to a useful and generally needed standard.

CONTROL CHART TECHNIQUE

No. 2564 : 1955. Price 10s. 6d.—This standard gives practical guidance on the use of quality control in all processes of manufacturing to a specification. It was originally written by Dr. B. P. Dudding and Mr. W. J. Jennett and first published by The General Electric Company, Ltd., in 1944, and now, with the permission of the director of the research laboratories of the G.E.C., it is now issued as a British Standard. The authors intend it to supplement B.S. 600R, which describes the statistical principle and methods used in quality control.

The new standard is essentially a practical manual describing procedures which have been found acceptable when introducing and operating quality control methods as factory routine. Its object is to assist production to a standard of quality, with the elimination of waste of labour and material.

The first part of the standard concerns the utilisation of results of measurement (quantitative data) and is of interest to manufacturing industry where articles or components are produced in quantity with dimensional limits of accuracy. The second part concerns the classification of a product by quality (qualitative data) and it is of use where sampling technique can be applied to regulate production.

Directions are given for the construction and interpretation of control charts appropriate to various processes and examples of some of the different cases met in practice are given.

Heavy-Duty Truck Development in the U.S.A.

By ROBERT CASS*

No. I

This James Clayton Lecture was read before the Institution of Mechanical Engineers, London, on March 11th. It discussed the principal factors which have influenced the characteristic features of heavy-duty vehicles in America. Sections deal with cab design, engine development, fuel pumps, gas turbines, transmissions, materials and suspension. Parts of these sections have been abstracted herewith.

Introduction

THE differences that exist between the United States of America and Great Britain in regard to their heavy-duty truck designs and application are in a very large measure the result of America's mushroom-like growth and the resulting complexity of laws governing her ground transport. The background against which the heavy-duty truck is pictured takes into account the following significant points :—

(1) *Geography and Topography.*—These result in a vehicle being called upon to travel practically continuously from San Francisco to Chicago—a distance of 2300 miles. During this run it must go over mountain ranges hundreds of miles in depth, the passes of which can be in excess of 13,000ft with varying temperature conditions—70 deg. Fah. at one end and 30–40 deg. Fah. below zero at the other.

(2) *Speed.*—All trucks engaged in over-the-road operation are usually thought of as being geared to a minimum speed of 50 m.p.h. with engines operating just below governed speed. There are many operations where a speed of 70 m.p.h. is considered to be practical in long-distance hauling, and to that end the vehicles must be capable of meeting those conditions.

(3) *Loads.*—These speeds and distances take into account gross vehicle weights (G.V.W.) of up to approximately 40 short tons with some areas calling for lower speeds with 50 short tons. These latter, however, are in the flatter terrains.

(4) *Laws.*—The restrictions are manifold and, without going into detail, suffice it to say that to be informed in regard to the different regulations throughout the forty-eight states dealing only with sizes, that is, length, width, height and capacity, calls for the study of an eighteen-page book. A typical example of this is that in vehicle combinations the legal differences in length alone can be as much as 20ft. It is with this in mind that you will view the vehicles shown [on subsequent slides] and will realise the necessity for many variations of a vehicle presumably doing the same work, and in many cases carrying the same loads, but needing different arrangements of components and also different components to enable this to be done.

(5) *Economics.*—All of this must be done with minimum capital outlay so far as equipment is concerned and, regardless of these complexities, within an all-inclusive cost range of 23–25 cents per mile in over-the-road service. The vehicles must also be built to be capable of running continuously for long periods of time and for twenty to twenty-three hours each day, allowing only the minimum time for service before the turn round or continuation of the journey. Furthermore, the weight restrictions are continually assuming more importance as rates become more competitive between rail and road transport and as more effective law enforcement enters the scene. The annual mileage of thousands of over-the-road vehicles is a very predominant factor in design as 100,000–120,000 miles a year is not unusual.

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Design Considerations

The most significant trend in chassis design during the last four or five years—a trend which is steadily becoming more and more evident—deals with the "cab-over-engine" type, or as it is sometimes called, "cab-forward-of-engine" type.

While past attempts to develop this vehicle relate to many years ago, the compromise which was necessary in those days never permitted it to become significant in numbers in those early days and, until recent times, the type suffered a severe decline in use. It did so because whilst attempting to meet the

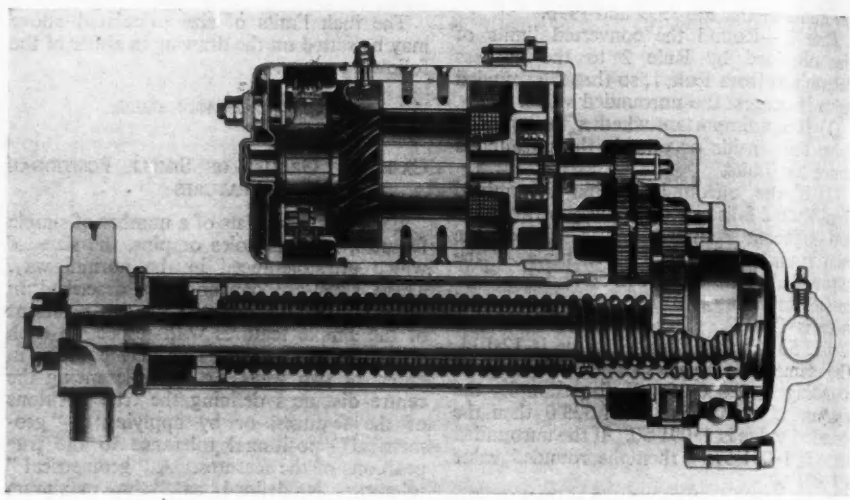


Fig. 3—Cut-away view of electrically-operated strut for tilting mechanism

Fig. 1—Tilting-cab model showing complete absence of interference with entire power plant

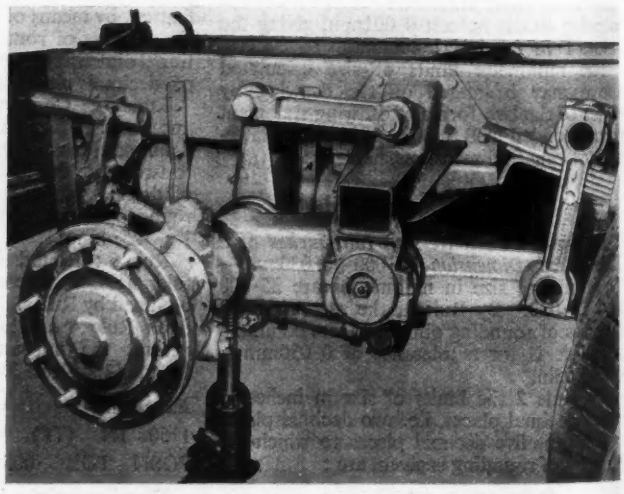


Fig. 2—Installation of arrangement of steering-pusher axle with single wheel and tyre removed

economical demands by having a foreshortened vehicle, the lack of accessibility, the lack of vision, and the hazard of entering and leaving the cab of the vehicle caused operators to disregard—wherever they could—the use of such vehicles. The inaccessibility was deplorable.

The next significant improvement following this basic concept of this type of vehicle is shown [slide]. A long, slender hydraulic jack or hoist is used to lift the cab, leaving the power plant quite well exposed. This was accomplished by an electric motor acting as the motive power and a two-way hydraulic system to both extend and return the hydraulic hoist to its respective up and down positions.

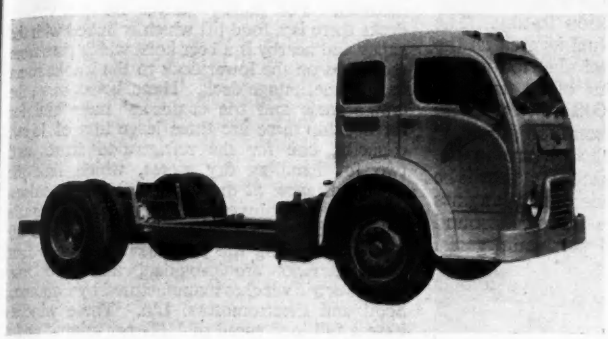


Fig. 4—Low bed chassis for use with palletised bodies

Just how the accessibility was handled is shown in Fig. 1, in which it will be seen that there is no interference whatever to servicing of the engine, and this tilting operation can be accomplished in fifteen seconds. A repair man can stand between the tyre and the frame side-rail and perform all service operations in a normal upright position.

The question of fumes, previously mentioned, was readily solved by the design which enables the steering gear, hand-brake and gear-shift levers to tilt with the cab and at the same time remain positively attached to their respective main component parts. This enabled the manufacturer to have a solid, level floor, and in this view it will also be seen that the engine is under the seat and, therefore, the more accurate description of the vehicle might be "cab forward of engine."

Fig. 3 shows a cut-away view of the electrically-operated strut for the tilting mechanism, and it may be of interest to learn that the device was a result of the 1939–45 war—having been designed to operate the bomb-bay doors on the "B-29s," It will be realised that the strut has to be well made and of rugged construction and, in general, the maintenance on it has been well within reason.

This type of vehicle—and there are at least three manufacturers at the present time producing tilting-cab models—permits the largest-size engines, that is, 200 h.p., to be used for highway operation.

Fig. 4 shows a specially designed version to make pallet loading possible; this fits particularly well into the industries which deal with delivery of consumer items to city outlets. The principal advantages of this palletised vehicle are: reduction in labour costs, increase in storage capacity within the plant, reduction in damage to containers as well as to product. The amount of time saving in loading and unloading of consumer products such as bottled goods of all kinds is very considerable, inasmuch as 85 per cent less labour man-hours are required. A further advantage of this low-bed chassis is the reduction in manual effort at points of delivery. It can be produced on the same assembly line as other models and its prime cost is very little more than a straight-frame chassis.

The heavy-duty trucks covered by the foregoing description are used where legal restrictions permit heavy loading on the front axle without relation to wheel-base length, and as much as 35 per cent increase in loading on the front axle becomes possible with this type of vehicle and the revenue possibilities are therefore quite considerable. Obviously, this also makes it possible—because of the 45ft. length limitations being so prevalent—to pull a larger container behind or mount a longer body on the chassis.

The subsequent illustrations show the lengths to which design has gone to permit the longest possible containers in this area. [A slide showed a vehicle with a 200 h.p. diesel engine as motive power depicting the engine radiator remotely mounted from the engine at the right side rear of the cab]. Tests made indicate considerably improved cooling in this position as compared to the conventional front-mounted radiator on a similar model with the same engine. The saving in length in this case amounts to roughly 7in.

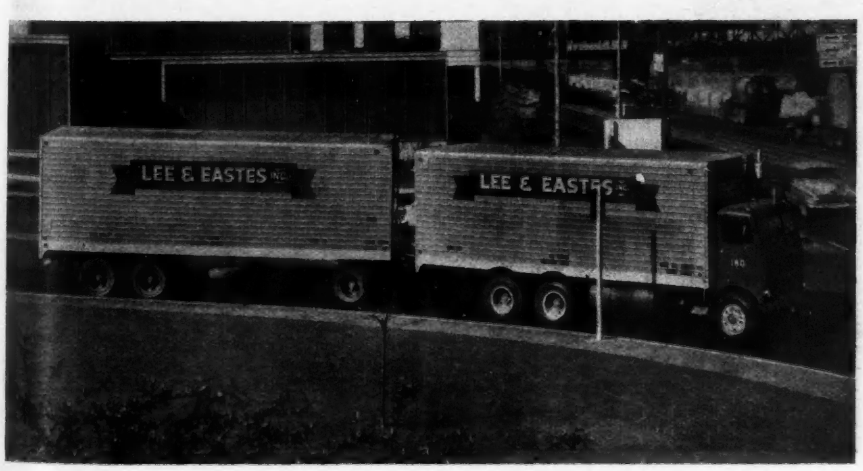


Fig. 5—Under-floor model—200 h.p. diesel with cab dimension depth of 48in

Fig. 5 shows the ultimate space saving, and at present this is the only vehicle of its type in the United States, with a 200 h.p. diesel engine mounted under the frame immediately rear of the cab, with a dimension of 48in from the back of the cab to the front bumper. This represents the minimum distance possible for comfort for the average driver in over-the-road operation.

Another version is shown in Fig. 6, and accessibility to the engine compartment is secured through removable hood arrangement seen on the left-hand side when facing the vehicle. The driver's vision is a significant factor in this design.

Another illustration—Fig. 2—covers an interesting development in regard to an additional axle, which might also be called

Fig. 6—Later model of cab-over-engine truck

front axle No. 2, inasmuch as it is a steering axle and has interchangeable knuckles, king pins and tapered roller bearings with the main front axle. It also is a single-tyred axle but has two particular advantages: (1) that it enables an additional 3½ short tons to be carried, and (2) that it has an operating advantage in that it allows tolerances in loading with semi-trailer operation to meet States laws covering axle loadings on the tyres of the vehicle. There are further advantages in that greater stability is noted in the operation of the vehicle under extreme weather conditions and also additional braking effort is provided.

It may be noted that because of the distance involved, there is a fairly large use of vehicles which contain a driver's sleeping compartment in the cab.

Petrol Engines

The use of carburetted engines in heavy-duty trucks falls into two classes—those using petrol and those using liquid petroleum gases. The horsepower range available and in use in trucks to-day in the heavy-duty field is roughly from 120 h.p. to 200 h.p., with some few 300 h.p. petrol engines being used for highway vehicles. The truck engines, as distinct from passenger-car types of engine used in trucks, are apt to be "L"-head in the smaller sizes and overhead as the power approaches 200 h.p.

The early engines of both types for heavy-duty trucks were not capable of long mileages between overhauls, valve replacements, &c.,

and the overhead type seemed, in those days, to be a necessity. To-day, engine parts such as pistons, valves, piston rings and bearings are good for amazingly high mileages without needing attention—particularly since the advent of the "Zero Lash" valve lifters, valve rotators, ni-resist insert pistons and tri-metal bearings.

There has to date been no extended use, in the heavy-duty field, of the V type engine except where passenger car engine adaptations are employed, but with all the factors—legal and economic—becoming more active—the need to reduce the length of the power plant may become so vital as to make the 200 h.p. V type engine a necessity. In that case the overhead valve engine would seem to be imperative.

Great strides have been made in the reduction in fuel consumption, and even the largest size engines, with a low point of around 0·5 lb of fuel per brake horsepower at road load, are quite common. The use of fuel injection has now distinct possibilities for future use and, if successful, it is expected that the margin between diesel engines and petrol engines will be considerably narrowed. The price of the injection equipment has retarded to a large extent the use of the petrol injection systems in the past. One of the most interesting developments—because the material is available as a by-product—has been the use of liquid petroleum gases in petrol type engines, employing both butane and propane, and engines of all sizes up to and including the 200 h.p. range are involved.

A price differential of 5 to 7 cents per U.S. gallon, as compared to other fuels, is an attractive one from the standpoint of ready conversion that can be made in existing engines, and many thousands of these heavy-duty vehicles are in operation to-day. The lack of deposits from the fuel as well as the automatically balanced fuel distribution is another argument in favour of its use, and mileages in excess of 200,000 miles with no major repairs are not uncommon in many operations. In general, the picture in the heavy-duty field in the United States will be that of a continued preponderance of engines using petrol with octane ratings around 88–90 Research and liquid petroleum gases.

(To be concluded)

Shaw Savill Liner "Southern Cross"

No. II—(*Concluded from page* 378, *March* 18*th*)

The Shaw Savill Line has taken delivery of the liner "Southern Cross," which is a one-class ship designed to carry a total of 1160 *tourist passengers in the company's round-the-world service to Australia, New Zealand and South Africa. The ship has an overall length of* 604*ft, a gross tonnage of* 20,200 *tons, and is propelled at a service speed of* 20 *knots by twin sets of double reduction geared turbines. These turbines develop a total of* 20,000 *s.h.p. when supplied with steam at* 500 *lb per square inch and* 800 *deg. Fah., and the whole of the machinery is installed right aft to give the ship an unusual profile.*

Ship and Hotel Services and Auxiliary Equipment

ON the saloon deck, between the forward and after restaurants, is the galley, which occupies the centre of the space, and associated service and food preparation rooms, which are located along the ship's side. Our illustration shows that a generous amount of space has been allocated to the cooking arrangements, which are designed for economic working. The equipment includes a six-oven range of 94·5kW loading and a 157·5kW ten-oven range; one 30ft and one 20ft hot press having a total loading of about 37kW; one set of four and two sets of six steam pressure ovens; three two-chamber bakers ovens; salamanders, stockpots and three double electric grids, all supplied by Henry Wilson and Co., Ltd.

J. J. Lane, Ltd., has been mainly responsible for the equipment in the laundry which occupies a large space at the aft end of the saloon deck and which can deal with all the requirements of the passengers and of the ship. There are three hydro-extractors, three washing machines, a calender and other ancillary equipment, including a continuous self-discharging dryer supplied by Lister Brothers, Ltd. For the convenience of passengers and to give quick service there are a number of air conditioned ironing-rooms fitted with quick-drying machines, while the crew have a separate laundry on the saloon deck forward. Ample provision has been made for looking after the health of the passengers and crew and towards the after end of the main deck, on the port side, is a hospital in miniature, the block, which is air conditioned, containing three wards, operating and treatment rooms, and accommodation for a doctor and nurses. In addition, a small house right aft on the promenade deck is arranged as an isolation hospital.

The ventilation arrangements throughout the ship have been the responsibility of Thermotank, Ltd., and this company has installed the large and comprehensive air-conditioning system which serves every cabin and passageway, the cinema, lounge, restaurants, hospitals, hair-dressing saloons, shop and crew's recreation room. There are twenty-seven units located in suitable positions throughout the ship to serve the system which operates in conjunction with refrigerating plant, installed by J. and E. Hall, Ltd., having a capacity of 9,000,000 B.Th.U. per hour, and which also works in the reverse heat cycle to heat the ship in cool weather. The same company has supplied the refrigerating machinery which maintains the insulated provision rooms, of about 23,500 cubic feet capacity, at temperatures ranging from 15 deg. to 45 deg. Fah., and also serves the insulated cupboards. The plant, which is installed in a large compartment on the tank top forward of the diesel generator room, consists of ten compressors with ancillary equipment arranged to form six machine units. Two single compressors each on its own bed-plate and driven by a 125 h.p. motor, form two units. The remaining four are in pairs in which a compressor is coupled to each end of a 250 h.p. motor, all being mounted on a common base-plate.

For the convenience of passengers, two lifts are available, each having a capacity of eight persons and capable of accurate levelling under all conditions of loading. The forward lift serves seven decks, rising from the swimming pool on the lower deck to the entrance on the lounge deck, while the aft unit serves five decks extending from "A" deck to the cinema lounge. The interiors of the lift cars are finished in a plastic material. For pantry service on the various decks there is a food lift which is linked with the galley and nearby is a beer hoist which rises from the stores on the lower deck to the smoke room bar on the lounge deck. Hand hoists serve the crew's mess and the engineers' mess and for storing ship there are three large lifts of 15 cwt capacity, one for the refrigerated stores and two for handling dry stores, which link the stores entrances at the ship's side on the saloon deck with the stores on the lower deck. Adequate baggage spaces are arranged forward and aft and for handling the passengers' baggage four 2-ton derricks are provided, and also four 3-ton electric winches manufactured by Laurence, Scott and Electromotors, Ltd. These winches have a full load speed of 110ft per minute and a light hook speed of 450ft per minute.

In addition to the four baggage winches the ship has two 7½-ton electric capstans located immediately aft of No. 1 hatch forward, and two capstans aft on the main deck. Stothert and Pitt, Ltd., supplied the capstans and also the windlass, which is driven by a 90 h.p. motor located below deck. The power units for capstans and windlass were manufactured by Laurence, Scott and Electromotors, Ltd., and this company also supplied the motors for the boat winches. The streamlined rudder is operated by a telemotor controlled electro-hydraulic steering gear, of the four cylinder Rapson slide pattern, built by Brown Brothers and Co., Ltd. Each of the two power units, consisting of an electric motor driving a V.S.G. variable delivery pump, is capable of full duty and the gear is arranged so that five combinations of hydraulic cylinders can be used. In common with most modern liners, the "Southern Cross" is equipped with Denny-Brown stabilisers and the gear, together with the necessary pumps, is fitted in a compartment, on the tank top about midships, to which access is gained by a centre line passage from the refrigerating machinery space. The fins, which are housed in boxes within the ship's hull when not in use, each have an outreach of 12ft by a fore and aft length of 6ft 6in and an area of 78 square feet. The working angle is 20 deg. each side of the middle position and there are two tilting pumps driven by 50 h.p. motors and a servo pump powered by

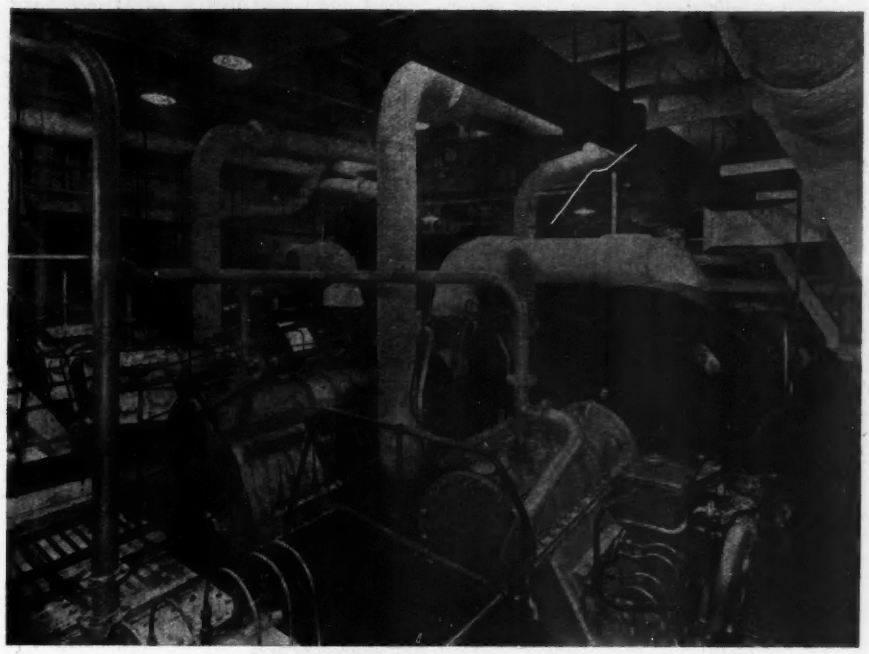
Galley showing island range and service arrangements

a 15 h.p. motor. The weight of the equipment is 123 tons and the load on one fin when tilted at an angle of 20 deg. in association with a ship speed of 20¼ knots, is 61 tons, and the righting moment applied to the ship is 5430 tons-ft. The sewage plant for the ship consists of four sets of twin "Centra-Syphon" expulsion plant supplied by Drysdale and Co., Ltd.

A total of nine hydro-pneumatically power operated watertight doors, which can be controlled from each side of the bulkhead and from the bridge, where there is an indicator board, are installed. In addition to the power-controlled installations, there are, on "A" deck, eleven hand hydraulically-operated doors, which are controlled locally and from the bulkhead deck by means of hand pumps. All the equipment was supplied by J. Stone and Co. (Charlton), Ltd. Fire precautions include: a Mather and Platt's Grinnell sprinkler system, zoning by the use of fire resisting doors and the Walter Kidde system, witn a remote visual and audible detector. Hugh McLean and Sons, Ltd., has supplied the complement of lifeboats, which consists of four 36ft lifeboats to carry 145 persons, two 32ft 6in boats to take 107 persons, seven 31ft boats to carry 99 persons and one motor-driven lifeboat for 70 persons, and two 26ft emergency lifeboats to carry 46 persons. All the boats are carried under Welin Maclachlan gravity davits, with wire falls controlled by one electric winch at each pair of davits. To assist in the navigation of the ship there are two Kent clear view screens, compasses and binnacles by Kelvin and Hughes, Ltd., Sperry gyro compass and repeater compasses, a comprehensive installation of radio communication equipment, radar and other aids supplied by the Marconi International Marine Communication Company, Ltd., and two whistles, one supplied by the Industrial and Mining Supplies Company, Ltd., and the other a "Secomak" electric unit, having a still air range of 4 to 5 miles. A complete system of sound reproducing equipment is fitted and The General Electric Company, Ltd., has supplied a 30/50 line automatic telephone exchange for communication between the ship's officers and senior personnel.

Main Propelling Machinery

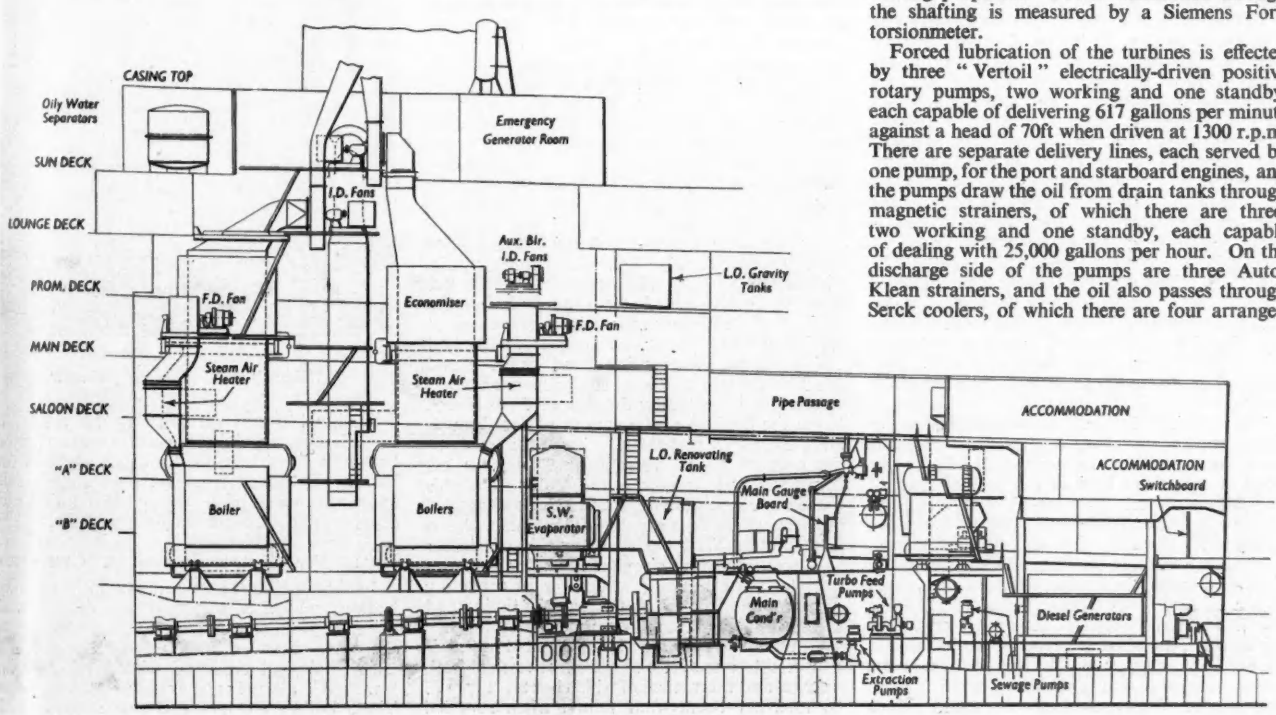
The shipbuilders have built the propelling machinery, which is under the charge of Mr. Owen L. Jones, the chief engineer, and which consists of a two-shaft arrangement of compound, condensing, double-reduction-geared turbines, designed to develop 20,000 s.h.p. at 120 r.p.m. of the propeller, when supplied with steam having a pressure of 500lb per square inch gauge at the superheater outlet and a total temperature of 800 deg. Fah. For astern working, the astern turbines provide 12,000 s.h.p. or 60 per cent of the ahead power. Our line drawing gives a longitudinal section through the machinery spaces, which are well arranged and very spacious and our illustrations show general views of the engine-room and starting platform.



Engine-room looking forward, showing gearing and turbine casings

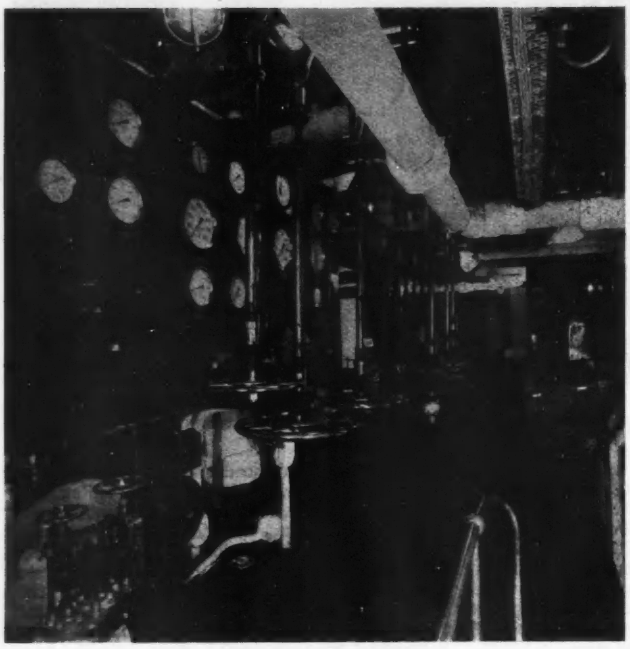
Each propeller shaft is powered by a compound turbine consisting of an impulse reaction h.p. turbine and an all reaction l.p. turbine. Astern power is developed by an h.p. astern turbine, which is an integral extension of the h.p. ahead unit, and exhausts into the l.p. astern stage, which is incorporated in the l.p. ahead turbine casing. Both astern turbines are of impulse design. The turbine rotors are of forged steel and the casings for both ahead and astern turbines are of cast steel, while the reaction blading is of stainless iron with stainless iron shrouding, mild steel packing and Lowmoor iron side locking strips. A flexible coupling of small tooth design connects each turbine with the pinion shaft, and the double reduction gearing has primary gears which consist of $^{7}/_{13}$in pitch, all addendum teeth and secondary gears of $^{7}/_{10}$in pitch deep form standard involute teeth. Each turbine drives its own pinion and the main gear wheels are built up, while the gearing is housed in fabricated gear cases. The Michell thrust blocks are arranged independently aft of the main gearing, and the forged steel shafting, which has diameters of 17¼in and 19⅞in for the intermediate and propeller shafting respectively, is carried in white metal lined self-lubricating bearings, and drives four-bladed, solid bronze alloy outward turning propellers. Power transmitted through the shafting is measured by a Siemens Ford torsionmeter.

Forced lubrication of the turbines is effected by three "Vertoil" electrically-driven positive rotary pumps, two working and one standby, each capable of delivering 617 gallons per minute against a head of 70ft when driven at 1300 r.p.m. There are separate delivery lines, each served by one pump, for the port and starboard engines, and the pumps draw the oil from drain tanks through magnetic strainers, of which there are three, two working and one standby, each capable of dealing with 25,000 gallons per hour. On the discharge side of the pumps are three Auto-Klean strainers, and the oil also passes through Serck coolers, of which there are four arranged



Longitudinal section through machinery space

in pairs, each pair operating in parallel, where it is cooled from 130 deg. to 110 deg. Fah. From the coolers, which are circulated with salt water from the discharge side of the main circulating pumps, the oil is discharged to two gravity head tanks, holding 1250 gallons each, and included in the system are two " Titan " 300 gallons per hour lubricating oil purifiers and an associated heater. A Hamworthy pump of 5 tons per hour capacity, against a 50ft head, transfers the oil from the drain to the renovating tank, and Cockburns, Ltd., has manufactured the man-



Engine starting platform

oeuvring, emergency and turbine exhaust valves.

The ship is equipped with the Weir Closed Feed System, with which is incorporated an evaporating and distilling plant capable of meeting all demands for water for domestic and boiler make-up purposes. Under each set of turbines is slung a Weir regenerative condenser, into which the l.p. turbines exhaust. Each has a cooling surface of about 8000 square feet and is designed to pass 55,545 lb of steam per hour and maintain a vacuum of 28½in with a sea temperature of 75 deg. Fah. with the turbines developing 20,000 s.h.p. The condensers, which have a deaerating effect and provide oxygen-free feed water for the boilers, have built-up steel shells and tubing of ¾in external diameter by 18 S.W.G. in thickness and are bolted to the l.p. exhaust. For circulating the condensers there are a total of four 20in " upright " centrifugal self-priming Drysdale pumps, each of 7000 gallons per minute capacity against a 22ft head. A direct-operated closed feed valve is fitted to each condenser and arranged for the automatic supply of make-up feed to the system and also for the automatic discharge of excess water in the system from the circuit to the feed tank, which is incorporated in the main turbine seating.

Three Weir " Lo-Hed " extraction pumps are fitted, one per condenser and one standby, and each has a maximum capacity of 117,000 lb per hour at maximum load and a normal load of 90,000 lb per hour. They are driven by an 18 h.p. motor running at 1650 r.p.m. and discharge the condensate through the air ejector, glands, condenser and drain cooler to the suction of the main feed pump, there being a branch connection to the distilled water storage tanks. Three-stage Weir " Maxivac " vertical inter-condenser pattern air ejectors, supplied with steam at 500 lb per square inch gauge, maintain the vacuum in the condensers and are circulated by the main condensate. With each ejector is a gland vapour condenser of 94 square foot surface which, in association with the ejector, is capable of dealing with vapour from gland pockets of one set of turbines up to 1000 lb of steam and air per hour, and of maintaining a vacuum on the outlet side of the main engine glands. There is one four-flow drain cooler which has an area of 400 square feet and cools the drains from the first stage of the triple-effect evaporating plant, the make-up evaporator and the l.p. and h.p. heaters, the cooling medium being the condensate on its way to the boiler.

There are one working and one standby Weir multi-stage, turbine-driven centrifugal feed pumps, each capable of doing the whole duty for all three boilers, at maximum power, and having a maximum output of 234,000 lb per hour against a discharge pressure of 700 lb per square inch gauge when running at 5350 r.p.m. There is also an assistant feed pump of 22,000 lb per hour capacity. The main pumps, which have a normal delivery of 180,000 lb per hour, discharge in turn through the condensate circulated distiller, the l.p. and h.p. heaters and the Weir robot regulator to the main boilers. The distiller, of 500 square foot surface area, condenses the vapour from the salt water evaporators and at the same time raises the temperature of 180,000 lb of condensate per hour from 130 deg. to 152 deg. Fah. At this temperature the feed water passes through the l.p. heater, which has an area of 350 square foot and where the heating medium is vapour from the make-up evaporator supplemented by steam bled from the main turbine. Now raised to 170 deg. Fah., the feed passes to the h.p. heater, which has an area of 600 square feet and uses steam tapped from the main turbines and also the drains from the bled steam air heaters to increase the temperature of the feed water to 240 deg. Fah. At this temperature the feed water is discharged to the boilers through Weir robot regulators, which automatically adjust the flow of feed water in accordance with the output of each boiler.

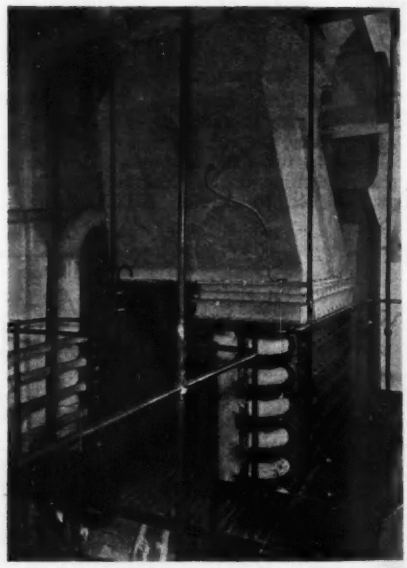
To avoid carrying large quantities of water for feed and domestic purposes, a triple effect evaporating plant is installed to provide single distilled water for domestic use and as feed to the make-up evaporators. The plant, which is rated to produce 300 tons of single distilled water per twenty-four hours, consists of three vertical salt water evaporators, each having a surface of 1050 square feet, the first effect being supplied with heating steam taken from the 20 lb per square inch gauge bled steam line at full power or from the 40 lb per square inch gauge line at service and low power. Vapour from the first evaporator serves as heating steam for the second effect evaporator and in a similar manner No. 3 evaporator is heated by the vapour from No. 2. From the final effect the vapour passes through an evaporator preheater, where the feed to the evaporators is raised from 75 deg. to 152 deg. Fah., and the vapour and drains from this preheater pass through the condensate circulated distiller which forms part of the main closed feed circuit. The drains from this condenser pass to a sea-water circulated distiller and part goes to a cooler, using salt water as a cooling medium, and from there through the liming and chlorinating plant to the domestic water tanks.

Another part of the single distilled water is delivered to one of two single-effect vertical fresh water evaporators, each of which has an output of 30 tons per twenty-four hours, when supplied with steam at 20 lb per square inch gauge bled from the main turbines, and a heating surface of 120 square feet. The vapour is led to the condenser in the main feed line in the discharge side of the main feed pumps and the drains pass to the drain cooler. Sludge from the evaporators is extracted by two electrically-driven pumps and for use with either of the evaporators is a sea-circulated distiller. To ensure continuous operation of the plant, Weir " Scalemaster " chemical treatment is fitted to inject chemicals into the sea-water to prevent the formation of scale on the coils of the three evaporators.

Included in the system are two 50 gallons per minute fresh water extraction pumps, two 140 gallons per minute feed salt water pumps and three 94 gallons per minute brine pumps.

Most of the auxiliary machinery is electrically driven, and the majority of the pumps have been provided by Drysdale and Co., Ltd. These include one general service and one water service pump, each rated to deliver 200 tons per hour against a 70ft head ; one 150 tons per hour, against 120ft head, bilge pump ; two ballast pumps, capable of delivering 250 tons per hour against a 120ft head ; two sanitary pumps of 55 tons capacity against a head of 134ft ; three transfer pumps, each rated to deliver 55 tons per hour against a 200ft head ; and a " Wee Mac " cooling water pump, having a capacity of 240 gallons per minute. There are also six " D.X.L." divided casing pumps, three for salt water, rated at 1667 gallons per minute, and three for fresh water, rated at 1250 gallons per minute, and three brine pumps, each of 167 gallons per minute capacity.

For handling the boiler oil, two " Vertoil " 330 gallons per hour transfer pumps are mounted, one in the engine-room and one in the stabiliser compartment, and for the diesel oil fuel there are two " Vertoil " transfer pumps, each of 42 gallons per minute capacity, installed in the port side of the generator room. The emergency fire and bilge pump is a vertical, centrifugal, submersible two-stage, self-priming unit, supplied by Worthington-Simpson, Ltd., and capable of



" Weldex " bled steam air preheater

delivering 140 tons per hour against a head of 70ft. Besides providing the centrifugal separators Ferguson and Timpson, Ltd., has supplied two Victor oily-water separators, which are fully automatic, electronically controlled units, each capable of dealing with 250 tons per hour.

Boiler Plant and Electrical Generators

In the spacious boiler room, seen in our illustration, which is arranged aft of the main machinery and on a flat above the shaft space, there are three oil-fired, water-tube boilers of Yarrow design, equipped with Weir high and low level alarms and cut-out arrangements. These boilers are mounted two abreast at the forward end of the room with one on the centre line further aft and all with the boiler drums

lying fore and aft. There are four burners per boiler, and each boiler is fitted with a " Melesco " superheater, a Weldex pre-heater and a " Senior " economiser. The primary and secondary sections of the economiser have a total area of 6190 square feet, and the bled steam air pre-heater, supplied by the Wellington Tube Works, Ltd., and shown in our illustration, is designed to raise the temperature of 69,900 lb of air per hour from 80 deg. to 270 deg. Fah. when supplied with bled steam at 50 lb per square inch gauge and 420 deg. Fah. The boilers have a total generating surface of about 27,800 square feet, and a total evaporation rate of 180,000 lb per hour, and are fitted with manually operated Clyde soot blowers using superheated steam. A spray pattern desuperheater is fitted and the boilers are designed for a steam pressure of 500 lb per square inch gauge at the superheater outlet, with a total temperature of 800 deg. Fah. Mono CO_2 recorders are fitted, and also Cockburns valves, and the Wallsend Slipway and Engineering Company, Ltd., supplied the oil burning plant, which consists of two sets, each of which can do the full duty of approximately 13,000 lb per hour at 300 lb per square inch. There are, in the boiler room, two oil fuel settling tanks, one to port and one to starboard, having a capacity of 157 tons and 172 tons, respectively.

Howden's system of forced draught is installed, and consists of three double inlet forced draught fans, driven by a 55 h.p. adjustable speed electric motor, and rated to deliver 22,000 cubic feet per minute against a discharge pressure of 7·7in water gauge. An electric motor of 180 b.h.p. drives each of the three single inlet induced draught fans, each of which can deal with 30,600 cubic feet per minute of gas against a pressure drop of 7·5in water gauge. In the closed top elliptical funnel an exhaust fan is arranged to discharge through an annular casing and to create a stream of air around the flue gases.

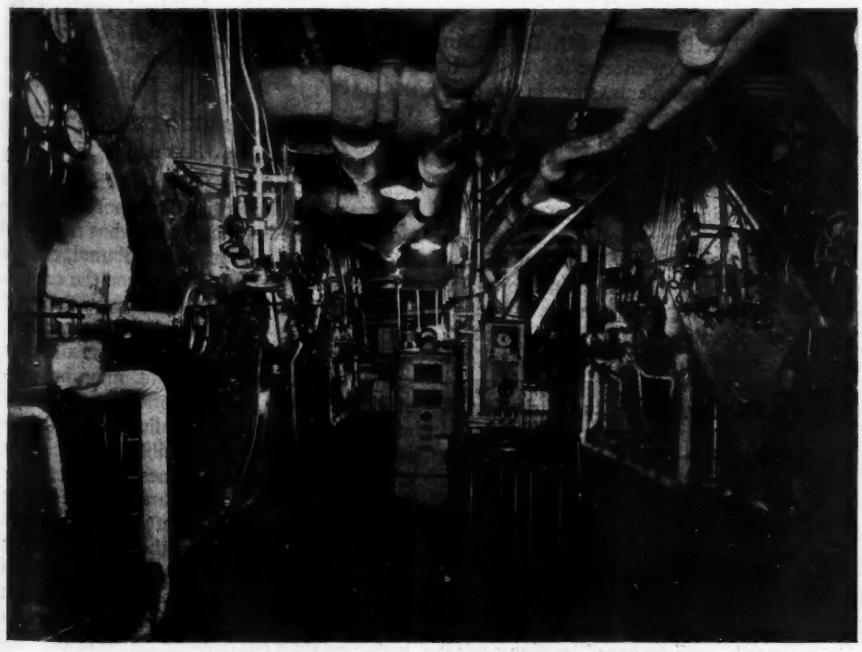
Steam for the auxiliary services is provided by two auxiliary boilers which are installed in a flat at the aft end of the generator room, and generate saturated steam at 80 lb per square inch gauge. They are composite boilers of Foster Wheeler design arranged to use the exhaust from the generators and also to burn oil fuel under forced and induced draught, the oil fuel installation being supplied by British Combustion Equipment, Ltd.

An auxiliary condenser, having a cooling surface of 600 square feet, deals with the contaminated drains and exhaust from the auxiliary boiler feed pump, and associated with the contaminated condensate system is a filter and hot well.

Three of the six diesel-driven generators

Feed water is supplied to the boilers by one electrically-driven two-throw pump, capable of discharging 22,000 lb per hour against 80 lb per square inch gauge, and as a standby there is a Weir direct-acting feed pump of similar rating. Weir high and low level controllers are fitted to the boilers, and also Weir-Mumford regulators. Six diesel-driven generator sets are installed in the generator room to supply the necessary power required for lighting, heating and cooking, and for driving the auxiliary machinery. The plant consists of Allen, single-bearing, open pattern d.c. generators, each having an output of 600kW at 220V and driven at 400 r.p.m. by a Mirrlees " K.8," naturally aspirated, eight cylinder-in-line engine, having a continuous output of 878 b.h.p. The generators, which are level compound wound and arranged for running in parallel, have bearings and magnet frames split about a horizontal centre line, and each generator and engine is mounted as a unit on a single fabricated steel bedplate. Each set is complete with silencer, fuel pump, lubricating oil pump, and a Serck oil cooler. Two Hamworthy fresh water circulating pumps supply cooling water to the engines on a closed circuit, incorporating tubular heat exchangers which are served by two salt water pumps of the same make. One heat exchanger, one fresh water pump and one salt water pump are capable of serving four generating sets simultaneously. A thermostatic alarm in the cooling water system and a pressure stat in the lubricating oil circuit have been fitted to each engine as a safety device. Starting air is delivered to two air receivers, one of 60 cubic feet and one of 11 cubic feet capacity, by two two-stage Hamworthy air compressors, each rated to deliver 28 cubic feet of free air per minute at 350 lb per square inch. Also in the generator room are three " Titan " purifiers for the generator lubricating oil and two " Vert-oil " diesel oil transfer pumps of 10 tons per hour capacity. The engines have dry exhaust, asbestos-lagged manifolds and the exhaust gases pass via the auxiliary boilers to Burgess silencers.

Triple pole circuit breakers, mounted on the main switchboard, protect the main generators, and power is distributed throughout the ship from the main switchboard to auxiliary switchboards and master boards. In a house at the aft end of the sun deck is installed an emergency generator, having an output of 200kW, and driven by a Harland and Wolff four-cycle, single-acting, radiator-cooled diesel engine, having six cylinders of 250mm diameter by 350mm stroke. The emergency generator, which is protected by a double-pole circuit breaker on the emergency switchboard, is arranged to supply a limited amount of power for lighting, heating, cooking, engine and boiler room auxiliaries when the main generators are shut down while the ship is in port. In the event of a failure of the main generators, there is an emergency 220V battery which is automatically connected to the bus-bars on the emergency switchboard, and which is able to maintain those services essential to the safety of the ship.



Stokehold looking from port to starboard, showing the boiler fronts.

TIPPED DRILLS FOR MASONRY.—An improved design of the " Durium " tipped drills for masonry, concrete, tiles, &c., is now being made by Rawlplug Company, Ltd., Cromwell Road, London, S.W.7. The new form of drill, which is available in a range of sizes from $^{6}/_{32}$in to 1in, has an acute helix with a specially shaped flute which serves to clear the drilled material quickly and prevent clogging or packing. For deep hole drilling purposes the drills of $\frac{1}{4}$in upwards are now available with a plain shank, for holding in a chuck in the usual way, and part of the shank threaded for the attachment of an extension rod. These rods are available to make possible the drilling of depths up to 12in or 16in, and their design is such that the mating threads cannot bind and no special tools are required to separate the rods and drills after prolonged use.

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LUBRICANTS FOR OIL ENGINES

In a paper read rather more than a century ago before The Institution of Mechanical Engineers, there will be found the following description of a new lubricating compound made up of "carefully refined southern whale oil as a basis, to which are added india-rubber and levigated white and red leads, to constitute a kind of metallic soap, possessing the necessary oleaginous lubricating property, adequate fluidity, and a body impenetrable by the pressure upon ordinary bearings. . . . . In the experiments made with this compound, it has been found that no pressure of bearing, or extreme of velocity, ever penetrated its substance, or produced any perceptible rise of temperature, and though it is gelatinous and as smooth as oil, its elastic body prevents penetration or displacement." The paper goes on to state that this compound was tested in two express engines on the Manchester and Crewe section of the London and North Western Railway, the cost of lubricant being one penny per journal per 1000 miles as compared with fourpence per journal per 1000 miles when using oil and tallow. It is to be noted that at the time in question, oil and tallow were almost universally employed in the lubrication of locomotive engines and had been so employed since the days of George Stephenson and Timothy Hackworth. We may be thankful that in the opening years of the mechanical engineering age a mixture of the kind referred to sufficed as a lubricant. Indeed, we wonder what the locomotive engineers of 1850 would have felt about such matters as viscosity index, flash point, ash content, carbon residue and oxidation stability. They might, we imagine, have been provoked to the utterance of some vivid running-shed language by the statement that :—

"In the centimetre-gramme-second (c.g.s.) system the unit of dynamic or absolute viscosity is the 'Poise.' It is more convenient to determine the kinematic viscosity which is the absolute viscosity divided by the density, the unit being the 'Stokes.' For many purposes the stokes is an inconveniently large unit, and viscosities are more commonly expressed in centistokes, that is one hundredth of a stokes."

The above passage is taken from the interesting paper read on March 17th before the Diesel Engine Users Association by Mr. J. S. Paten and Mr. A. V. Driver. We quote it along with the antique prescription not in any facetious sense, but as evidence of the profound change which has taken place in the problems of lubrication and in the creation of lubricants designed to cope with them. Mr. Paten and Mr. Driver are dealing, of course, with one of the most complex of these problems, since in the case of the heavy-oil engine the same lubricant has, in the great majority of instances, to be used not only for the lubrication of the crankshaft and motion work bearings but for the lubrication and sealing of the sliding surfaces within the cylinder. It will be acknowledged that the suppliers of lubricating oil have not spared themselves in efforts and expenditure directed to producing lubricants for engines operating under conditions which are highly conducive to deterioration of the oil. It was remarked—many years ago—by Dr. W. R. Ormandy that a lubricating oil did not suffer deterioration by continued use, but that changes inimical to its quality as a lubricant were due to oxidation and to the introduction of foreign material brought in from the cylinder or elsewhere. This is confirmed by the paper now before us, according to which what are called "heavy duty" oils find their main applications in : (1) the small high-speed engine ; (2) the highly rated medium-speed engine ; (3) engines in which poorer quality fuels are in use. We note the statement that the primary function of "detergent" additives "is to prevent the formation of deposits rather than to remove pre-formed deposits" and we agree with the authors that the word "detergent" does not afford an accurate picture of the function of such additives. If detergent—from the Latin *detergeo*—means anything it means to "wipe-off" and it would be desirable to omit the word "detergent" where the idea of wiping-off does not arise.

Greatly as we can admire the sustained efforts of petroleum technologists to arrive at lubricating oils capable of dealing with the severe conditions obtaining in some of the engine types mentioned by Mr. Paten and Mr. Driver, much remains to be said for the principle of so designing and operating the engine as to render it as little sensitive as possible to damage whether from overheating, corrosion, or any other adverse condition such as abrasive dirt carried in with the air. We note, further, the timely warning sounded by the authors as to the need for preventing dilution of the crankcase contents by fuel oil. The authors state that "a dilution of 5 per cent with gas oil can reduce the viscosity of an S.A.E. 30 lubricating oil to that of an S.A.E. 20 grade." This is a hint to engine manufacturers as well as engine users, particularly in view of the large current production of quick-revolution, multi-cylinder engines in which the number of injections per second is startlingly high. A leaking fuel injection pump is a nuisance at any speed and for more reasons than that of crankcase dilution. Moreover, among the hazards in trunk-type engines is blow-by during both the compression and working strokes, the effects of which need no emphasising. What needs emphasising is the desirability of using, wherever possible, engines which have been designed with a view to operating with the highest degree of reliability, the lowest maintenance cost and the utmost economy in lubricating oil. One wonders what effect there might be on engine design and details—including accessory equipment—if it became part of the engine builders' contract to provide all the lubricating oil required for the first 3000 hours' operation of the engine.

THE RAILWAY FREIGHTS SCHEME

It will be some little while before the full implications of the new freight charges scheme which the British Transport Commission has worked out, and which has now been submitted to the Transport Tribunal, can be properly assessed. Indeed, since the scheme relates only to maximum charges and not to the charges that will actually be made—which are likely to be below the maxima for nearly all commodities and may be substantially below them if private agreements are entered upon with individual traders—it will not really be possible to assess the effect until the scheme comes into operation. Yet though it would be unreasonable to give too much weight to the actual charges listed in the scheme, the new method of calculating the charges does deserve attention. For it amounts to a profound breach with the past and is likely to result in considerable changes in the relative charges for differing commodities. That, indeed, is one of its objects.

For the Transport Act of 1953, under the terms of which the new charges scheme has been drawn up, not only envisaged that the country would be best served if road and rail transport were to compete, but also that if the railways were to compete effectively, they must be relieved of disabilities, as common carriers, imposed upon them at the time when they had a monopoly of inland carriage.

While the railways had a monopoly of inland carriage, charges were not directly based upon the cost of carrying a particular commodity. The principle involved was that of charging "what the traffic would bear." The present system of charges still embodies that conception. The broad principle is to average the cost of carriage over all the traffic, make each traffic contribute towards total expenses according to its ability to pay, and fix the charges at such a level that some predetermined net annual revenue will be obtained. But in a competitive world, that principle necessarily puts the railways at a disadvantage as against road transport. The road hauliers calculate their rates under no such principle; and the railways complained between the wars that, in consequence, road transport was stealing away from them the "cream" of the traffic, that traffic for which rail freights were high. They were being left only with those traffics which formerly had, in effect, been subsidised. Nor satisfactorily could they restore the situation by raising freights, since all freights were likely to be affected and the result could only be the diversion of yet more traffics to the roads. Thus, now that the railways have been freed of certain statutory obligations, the breach with the past in the method of fixing of freights is going to be profound. The maximum charges scheme relates, in terms of present-day receipts, to about 85 per cent of the total traffics covered by the scheme. There is no division into differing categories of commodities attracting differing rates for carriage. Two factors only are considered, weight and "loadability," respectively. "Loadability" is defined as the weight of the material that can be accommodated in a 10-ton wagon of 450 cubic feet capacity. The lowest maxima apply to consignments of 10 tons or more having a "loadability" of 10 tons or more; and the maxima increase rapidly per ton as weights and "loadabilities" fall below 10 tons. Each maximum charge consists also of two parts, a high charge for the first 10 miles or any part thereof, which reflects the influence of terminal costs, and low charges for each additional mile beyond 10 miles. The combination of these factors results in charges that favour full wagon loads as against part loads, and commodities of high "loadability" as against low; and the arrangement provides for a steep reduction in charges per ton-mile with distance carried—a substantially steeper reduction than that provided by existing standard charges. The scheme is thus designed to reflect in the charges more or less accurately the actual costs of railway working; and though the charges actually levied are likely to be below the maxima they will no doubt be based on the same classification.

But a charges scheme for the railways must not only reflect real costs; it must also be of such a nature that railway servants, varying widely in intelligence, can interpret it, and that traders making use of the services can estimate costs. Judged by these criteria, the scheme seems simple enough. Yet doubt may be expressed about "loadability." The definition of this quality, which appears, in fact, to amount to weight per cubic foot as loaded in a wagon, is so phrased in a Schedule to the Charges Scheme that only those with some experience of legal circumlocutions are likely to learn much from it. But probably the wording does not matter. For "loadability" is not a quality easily assessed, since it is related to volume as well as weight, to fragility (as, for example, when the commodity cannot be stacked), and even to shape, since awkwardly shaped articles take up much more space than their intrinsic volume. It thus seems that the railways will need to compile lists laying down accepted values for the "loadability" of particular commodities; and whether or not the commodities are packaged and how packaged may have a bearing upon the cost of carriage. Yet leaving this complication aside—and leaving aside, too, considerations as to how the new charges are going to be introduced without disturbing many trading activities—the Scheme does seem to provide the railways with a flexible, practicable, and easily understood system of levying charges. Moreover, it is one within the terms of which it should prove possible to quote special rates in such a way that the value of the concession is easily discern. Quite clearly, too, from the nature of the scheme, the railways are concentrating on attracting to themseves the long-haul traffic rather than the short haul, the bulk traffic rather than odd items. It is in longer hauls—of bulk traffic in particular, but of other traffic also to some extent—that the railways should best prove capable of competing with road haulage. If they prove capable also of speedy haulage, as is envisaged under the Railway Plan, they will compete even more effectively.

Obituary

ENGINEER CAPTAIN E. C. SMITH

We have learned with regret of the death of Engineer Captain Edgar Charles Smith, R.N., ret., which occurred on March 13th at his home at Keepers Corner, Burstow, Surrey. He was eighty-two. Engineer Captain Smith received his technical training at Finsbury College, and joined the Navy in March, 1895. During one period of his service he was instructor in steam in H.M.S. "Britannia," and was subsequently assistant to the chief engineer of Hong Kong dockyard, and assistant engineer manager at Devonport dockyard. From 1917 to 1922, Captain Smith was an examiner in the history of inventions for the Civil Service Commissioners. In addition to his long period of service as a naval engineer, Captain Smith devoted much of his time to writing and lecturing on the history of engineering, on which he was an acknowledged authority. He was keenly interested in the work of the Newcomen Society for the Study of the History of Engineering and Technology, of which he was a founder-member and a past-president. To that Society he rendered many services and, over the years, contributed several valuable papers to its *Transactions*.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

REPORTS FROM THE FOOTPLATE

Sir,—Like your correspondent, Mr. A. M. Conybeare, I enjoyed Dr. Tuplin's article. Although I was not a driver, I am a survivor from the locomotive running department of the "heroic" period of the Great Central, and I can assure Mr. Conybeare that the spirit among its locomotive men was admirable. However, I would like to point out that the enthusiasm engendered by recording locomotive performance from the comfort of a first-class compartment, allied to the vicarious pleasure derived from occasional footplate trips, is considerably modified when one has to endure the discomfort of driving for a living.

G. Wynn Hamel, M.I.Loco.E.

London, S.W.5.
March 21st.

Sir,—I am writing to congratulate Professor Tuplin on his article, "Reports from the Footplate," which appeared in your issue of March 11th, and to thank you for publishing it. I found the article exhilarating and fascinating and by far the best written account of a locomotive run that I have read. May I add that I heartily agree with his remarks concerning the dull and uninteresting form in which such reports usually appear and hope that this will be the first of several such articles written by Professor Tuplin.

G. P. Jones

Ealing, London, W.13.
March 21st.

Sir,—Dr. Tuplin's contribution in your issue of March 11th, on "Reports from the Footplate," is a breath of fresh air, even to an agricultural engineer who reads locomotive articles from a purely escapist point of view. After literary criticism *à la* Beerbohm he comes out with a story which is only comparable to Kipling!

Peter Vanneck

Claydon, Suffolk.
March 18th.

Books Received

Chemical Engineering Processes and Equipment Edited by E. Molloy. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

Steam, Air and Gas Power. Fifth edition. By W. H. Severns, H. E. Degler and J. C. Miles. London: Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 52s.

Analysis of Deformation: Volume II, Experiment and Applied Theory. By K. Swainger. London: Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 70s.

Diesel Engine Operation and Maintenance. By V. L. Maleev. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 61s.

The Story of Tire Beads and Tires. By W. E. Burton. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 40s.

Basic Television Principles and Servicing. By B. Grob. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 64s.

Engineering Dynamics: Volume I, Theory of Elasticity. By C. B. Biezeno and R. Grammel. Glasgow: Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 50s.

Practical Mathematics for Students of Science and Engineering. Volume I. By C. C. T. Baker. London: English Universities Press, Ltd., St. Paul's House, Warwick Square, E.C. 4. Price 7s. 6d.

Metrologie Générale: Volumes I and II (Grandeurs, Unites et Symboles). By M. Denis-Papin and J. Vallot. Paris: Dunod, 92, Rue Bonaparte (VI^e), Paris. Price 480F. each volume.

International Journal of Abstracts on Statistical Methods in Industry. Vol. I, No. 2. Published by the International Statistical Institute, 2, Oostduinlaan, The Hague, Holland. Price 7s. 3d.

Institution of Mechanical Engineers

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1954

Last Friday, March 18th, the Council of the Institution of Mechanical Engineers presented its annual report on the work and progress of the Institution during 1954. The total membership of the Institution as revealed by the accompanying table had reached 42,674 by the end of the year 1954.

Netherlands Summer Meeting

THE Summer Meeting was held in the Netherlands from Tuesday, June 15th, to Friday, June 18th, and 249 members accompanied by 144 ladies, registered for the meeting. The headquarters were at Scheveningen, near The Hague. This was the first Summer Meeting to be held outside the British Isles since 1932. The Council wish to place on record their grateful thanks to the many generous hosts, also to the Netherlands Railways and the Koninklijk Instituut van Ingenieurs, whose efforts contributed so largely to the success of the Summer Meeting.

The Institution of Mechanical Engineers Act, 1954

The Bill for the removal of doubts as to the validity of the amalgamation of the Institution of Automobile Engineers with the Institution of Mechanical Engineers and as to the validity of an increase of the subscriptions payable to the Institution of Mechanical Engineers; and for other purposes, was read for the first time in the House of Commons on February 2, 1954, and for the second time on February 18, 1954. The next stage was for the Bill to be considered by the Examiner of Private Bills, and should have been reached on February 23, 1954, but in the meantime a Memorial had been lodged on behalf of an Associate Member, complaining of non-compliance with Standing Order 63 of the House of Commons. The Examiner heard this member's Memorial on March 5th, and he ruled that the objections set out in the Memorial were not valid. The Bill then went before the Unopposed Committee of the House of Commons on March 18th, and was accepted by that committee without amendment or question. The Bill eventually received the Royal Assent on April 14, 1954, immediately prior to the Easter Recess, and became operative as The Institution of Mechanical Engineers Act, 1954.

Alterations to Royal Charter and to By-laws

Following on The Institution of Mechanical Engineers Act, 1954, the Privy Council, in May, 1954, approved the alterations to the Royal Charter and to the By-laws of the Institution made by Corporate Members at the Special Meeting on October 5, 1951, the main object of which was to provide for polls to be taken by means of postal voting papers. The alterations have been embodied in the existing By-laws, reprints of which were made in June, 1954.

Revision of By-laws

The revision of the By-laws of the Institution was continued during the year, and on October 5, 1954, a copy of the complete set of draft new By-laws proposed by the Council, together with explanatory notes, and a message from the President asking for comments on the draft, was sent to Corporate Members. By the end of the year most of the comments received had been considered by the Council, some useful suggestions had been embodied in the draft, and this work was proceeding with a view to submitting a final revised draft to Corporate Members for approval at a Special Meeting which, it was hoped, would be held in March, 1955.

The Commonwealth Engineering Conference

The Commonwealth Engineering Conference met in London from May 24th to June 4th, the Institutions of Civil, of Mechanical, and of Electrical Engineers acting as hosts. The Conference was attended by delegates accompanied by their ladies from the Engineering Institutions of Australia, Canada, India, New Zealand and South Africa, in addition to those representing the home Institutions. A representative from the Rhodesian Society, which has since become a member society, attended as an observer. In the course of its ten business sessions, the Conference discussed a number of matters of interest to its constituent Institutions, their members, and the public they serve. These ranged from matters such as the proper conservation of natural resources, a question of prime importance to everyone, to more detailed questions concerning the recruitment, education and training of professional engineers and of engineering technicians, and measures to secure internationally the most effective interchange of lecturers and speakers on engineering subjects. The next meeting of the Conference will take place in Australia in 1958 at the invitation of the Institution of Engineers, Australia, supported by the New Zealand Institution of Engineers.

Membership of the Institution of Mechanical Engineers

	Hon. M.	M.	A.M.	C.	Assoc.	G.	S.	Totals	
Totals at December 31, 1953	34	4,808	17,087	33	902	14,062	4,153		41,079
Elected	3	29	274	1	12	1,187	983		
Reinstated	—	1	3	—	1	1	4		
Transferred	—	175	1,164	—	—	674	—		
Total additions during 1954	3	205	1,441	1	13	1,862	987	+4,512	
Deceased	3	106	117	1	3	10	7		
Resigned	—	10	34	—	11	92	100		
Erased	—	7	25	—	9	45	84		
Elections voided	—	—	—	—	—	6	20		
Transferred	—	—	173	—	11	1,141	688		
Lapsed	—	—	—	—	—	61	153		
Total deductions during 1954	3	123	349	1	34	1,355	1,052	−2,917	
Net alterations during 1954...	—	+82	+1,092	—	−21	+507	−65		+1,595
Totals at December 31, 1954	34	4,890	18,179	33	881	14,569	4,088		42,674

Second European and United States Engineering Conference on Engineering Education and Training

The second European and United States Engineering Conference on engineering education and training was held in Zurich from September 27th to October 1st. The Institution was represented by Professor E. Giffen, D.Sc., Ph.D. (Member of Council), and the Secretary. In preparation for the forthcoming plenary session of E.U.S.E.C. to be held in Copenhagen in September, 1955, and for the session on education and training to be held in Paris in 1956, preliminary discussions led to the formation of working parties:

(*a*) To produce a glossary of terms used in the countries concerned and applicable to the training of professional engineers.

(*b*) To produce a report on the standards of attainment accepted from school-leavers in the countries concerned as entry standards to professional engineering courses at University level.

(*c*) To report on engineering courses at university level in the various countries.

The subjects of discussion also included the practical training of engineering students of university level, international exchange of students, post-graduate engineering education in technology and management, the criteria applied in the various countries for recognition as professional engineers, the communal and civic responsibilities of professional engineers and the foundation of a permanent conference concerned with engineering education and training.

Codes of Practice Council

As was announced in the press in March, 1954, following discussions between the Ministry of Works, the existing Codes of Practice Council for Buildings, the professional institutions concerned and the British Standards Institution, it was agreed that a Council for Codes of Practice should be established within the British Standards Institution to be responsible for all work on Codes of Practice.

The new Council came into being on March 30, 1954, with Mr. Alan S. Quartermaine, C.B.E., B.Sc., Past-President of the Institution of Civil Engineers, as Chairman. This Institution's representatives on the Council are Mr. A. C. Hartley, C.B.E., B.Sc. (Eng.) (Past-President), and Dr. S. F. Dorey, C.B.E., Wh.Ex. (Past-President), F.R.S., and at the initial meetings a sound foundation was laid for future procedure. Four Codes of Practice Committees have been set up, one being the Mechanical Engineering Codes of Practice Committee. This Institution has six representatives on this committee and its chairman is Mr. A. C. Hartley.

The detailed work of drafting codes will be delegated to Technical Committees and panels which will report to the Mechanical Engineering Committee and thence to the Codes of Practice Council.

Parsons Memorial Lecture

The Parsons Memorial Lecture was instituted in 1935 under the auspices of the Royal Society. It is delivered each year in one of the branches of science to which Sir Charles Parsons contributed, and is sponsored by the institution or society appropriate to that subject.

The centenary of the birth of Sir Charles Parsons occurred during 1954, and it also fell to the Institution to arrange for the delivery of the Nineteenth Parsons Memorial Lecture. This was delivered in October, by Mr. Frank Dollin, B.Sc. (Eng.) (Member), his subject

being "Factors Influencing the Continuing Development of the Steam Turbine."

Specialist Groups

The work of the Specialist Groups was continued throughout the year, and a high proportion of the general meetings were held in collaboration with one or more of these groups. Once again many of the papers discussed were initiated by Group Committees. Seventeen general meetings were arranged in conjunction with groups, as follows :—

Applied Mechanics	6
Industrial Administration and Engineering Production	5
Hydraulics	3
Internal Combustion Engine	2
Education	2
Steam	1

Automobile Division and Group Discussions.—The Automobile Discussions and Group Discussions held towards the end of 1953 proved so successful that they were continued throughout 1954. These differ from the ordinary general meetings in that no formal papers are presented and no record of the discussions is taken. Subjects for discussion are selected by the Group Committees, and are often chosen for their topical interest. The attendances were high throughout the year, and a large proportion of those present made contributions.

Whole-Day Conference

A whole-day conference on hydraulic mechanisms was held at the Institution on Friday, March 26th, during which seven papers were presented for discussion. The theme of the discussion was positive displacement oil-hydraulic machinery for power transmission.

The House of the Institution

On February 26th a suite of rooms, consisting of the James Watt Room, the Stephenson Room and the Presidents' Gallery, was officially opened in the presence of the President of the Royal Society, Dr. Adrian ; the President of the Institution, Mr. A. Roebuck, and members of the Institution. The ceremony took place in the James Watt Room, which contained, through the generosity of Mr. Nelson Haden, a beautifully executed bronze bust of James Watt. The bust was unveiled by Dr. Adrian during the ceremony.

James Clayton Fund

Award of the 1953 *James Clayton Prize.*—The will provides that a sum not less than one-quarter of the annual income shall be awarded as a prize to a member, associate member, graduate or student who, in the opinion of the Council, has contributed most in the year to modern mechanical engineering science by way of research, invention or experimental work, or by a treatise or paper on a modern mechanical engineering subject, or by originality in design, or by service to mechanical engineering.

The sum allocated for award by the Council for the purpose during 1953 amounted to £1617, and the Council decided that the prize be divided and awarded equally to A. T. Bowden, Ph.D., B.Sc. (Member), for his contributions to mechanical engineering in the field of steam and gas turbines, and to T. W. F. Brown, D.Sc., S.M. (Member), for his contributions to marine engineering in the field of steam and gas turbines.

James Clayton Lecture.—A James Clayton Lecture was delivered by Mr. G. W. H. Gardner, C.B.E., B.Sc. (Member), of Britain.

Awards Under the James Clayton Bequest and Research Fund.—In June, 1954, six new Fellowships (two of these to candidates from overseas), three new grants, and three extensions to existing Fellowships or grants were awarded under the terms of the James Clayton Bequest and Research Fund. One Fellowship and one extension to a Fellowship were subsequently not taken up. The value of the Fellowships and grants was approximately £6000.

Work Carried Out by James Clayton Fellows During the Year : (1) Special Experience in Industry

Visits were made to steel works in Britain, on the Continent, Canada, and the United States to study modern practice in the manufacture of steel plate ; to oil refineries in Britain to study lubrication, and to firms in the United States to study heavy constructional equipment. Visits were also made in Britain to manufacturers and operators of public service vehicles, and to firms concerned in the manufacture of cranes and auxiliary equipment.

(2) Research Programmes

Dundee Technical College.—An investigation was continued into the pressure and velocity distribution in a roto-dynamic pump.

King's College, London.—The design and construction of a hydraulic transmission for motor vehicles was carried out.

Imperial College of Science and Technology.—An investigation was made on three-dimensional losses in a cascade of aerofoils. An investigation was also carried out on plastically deformed materials, and another on flame radiation from pulverised coal.

Queen Mary College, London.—Research was continued on heat transfer between a cylinder and a liquid in cross flow.

Prize for Papers on the Subject of Filtration

The Council have received and accepted an offer from Mr. C. G. Vokes to endow a prize to be awarded, at the discretion of the Council, for papers dealing with the subject of filtration. The "Filtration Prize" will be awarded annually or at such times as the Council may decide, for a paper on filtration or allied subjects including filtration of solids from fluids, the separation of dust particles from fluids by electrostatic or other means, research into particle size analysis and research in matters connected with these subjects. It is intended to create a trust fund from which to administer the award.

Kelvin Medal, 1953

The Kelvin Medal Fund is administered by the Institution of Civil Engineers and the award is made by a committee of the presidents for the time being of the participating institutions after they have considered recommendations from similar bodies in all parts of the world.

The Kelvin Medal for 1953 was awarded to Dr. Chalmers Jack Mackenzie, C.M.G., M.C., F.R.S., F.R.S.C., M.E.I.C., and the presentation took place on June 2nd at a meeting held in the Institution. Field-Marshal the Right Hon. Earl Alexander of Tunis, K.G., G.C.B., G.C.M.G., C.S.I., D.S.O., M.C., made the presentation.

Benevolent Fund

The attention of members is again drawn to the work of the Benevolent Fund in the confident hope that members will continue their generous support of this worthy cause. Members who are not already subscribers to the Fund are asked to join and in that way help the Committee of Management in the work they undertake for the Fund. During 1954 a sum amounting to £9496 was granted to ninety-two cases. As the Institution bears the cost of administering the Fund, practically the whole of each subscription received is applied to the allowances and grants. In connection with the latter the Committee of Management have continued to assist with the education of the children of deceased members.

Publications

Proceedings.—On the completion of *Proceedings* (A), Vol. 167, in March, and of *Proceedings* (B), Vol. 1B, in April, with issue No. 12, a new system of publishing the Institution's *Proceedings* was adopted. Starting with *Proceedings* 1954, Vol. 168, papers presented at meetings, or for written discussion, and certain others, have been issued as separate parts of *Proceedings*. The coloured covers relating to the Specialist Groups, and with which members are familiar, have been retained. During 1954 twenty-eight of the forty parts comprising the separate issues of Volume 168 were published. The Council have also decided to make bound volumes of *Proceedings* available to members and these will comprise a record of the Institution's technical contributions.

The Chartered Mechanical Engineer.—The *Journal of the Institution* ceased publication in its old form in December, 1953, and was superseded by a new journal, *The Chartered Mechanical Engineer*.

In planning the new journal the Council had in mind the necessity to produce a more useful and attractive publication, and adopted the principle of publishing summaries of all the Institution's papers with the purpose of providing technical information in a quickly assimilable form.

Another feature of *The Chartered Mechanical Engineer* is the inclusion of lectures and addresses in full which will also be published in the bound volumes of *Proceedings* made available by the Institution.

Library and Reading Room

The Library has maintained its progress throughout the year and the increased membership of the Institution has created an even heavier demand on the services provided. In this connection it may be recorded that loans to members have reached an all-time record of 15,745. In addition, some 1415 searches for specialist information have been made by the staff, many requests having come from members resident overseas. The total accessions recorded during the year amounted to 2737, which brings the complete stock to over 56,000. Details of many of these additions, with annotations, have been recorded in *The Chartered Mechanical Engineer*. Co-operation with other organisations—both at home and overseas—through the exchange and presentation of publications has continued, and it is interesting to reflect that publications received in this way emanate from nearly forty different countries.

At the beginning of the year bookcases in the east annex were rearranged to provide for the installation of a staircase giving direct access from the Library to its east gallery, an improvement which members and staff have found both convenient and useful.

Much use has also been made of the periodicals in the Reading Room where 400 current issues are exhibited. Many of these are subsequently bound for permanent preservation, and the number of such volumes bound during 1954 was 470.

During the year under review plans have been formulated for some reconstruction and refurnishing of the Reading Room to provide more comfortable accommodation

for members, and it is hoped that this work will be completed before the commencement of the 1955–56 session.

Conference on Mechanical Engineering as a Profession

The Institution invited headmasters, careers masters, and science teachers from the London area to a conference, arranged by the Education Committee, held at the Institution on Tuesday, December 7th, when Sir Ewart Smith, M.A. (vice-president), Mr. T. A. Crowe, M.Sc. (vice-president), and Major-General S. W. Joslin, C.B., C.B.E., R.E.M.E., M.A. (member), spoke about the scope and opportunities in mechanical engineering at professional level for boys with a public or grammar school background. The attendance at the conference included fifty representatives from forty-five schools in the London and Home Counties area. The conference was followed by an evening discussion on "Recruitment from the Secondary Grammar Schools," which was opened by Mr. C. W. Tonkin, B.Sc. (Eng.) (member), and at which there was an attendance of 115 members and visitors.

Joint Part I Examination

In September the Council announced that they had become a partner with the Councils of the Institutions of Civil Engineers and of Electrical Engineers in the conduct of a Joint Part I Examination.

The existing arrangements for Sections A, B and C would be continued until and including the examinations to be held in October, 1956, although candidates might, on request, take the new Part I in place of Section A on and after April, 1955.

Electrical Engineers' Exhibition

No. III—(*Concluded from page* 389, *March* 18*th*)

THE fourth Electrical Engineers' Exhibition, sponsored by the Association of Supervising Electrical Engineers, was held at Earls Court last week and closed on Saturday, March 19th. With the following description of some of the interesting exhibits we conclude our review of the exhibition.

English Electric Company, Ltd.

A comprehensive protective system for three-phase fractional horsepower motors was demonstrated by the English Electric Company, Ltd., Marconi House, Strand, London, W.C.2. The operation of this protective device depends on the familiar fact that any unbalance in the circuit of a three-phase star connected motor will produce a voltage between the neutral point of the motor windings and the supply neutral. This effect is produced whether the condition is due either to any unbalance of the supply voltage or to a winding fault causing an unbalance in winding impedance and thus unbalanced phase currents. It follows, therefore, that a trip (either thermal bimetal or solenoid-operated) connected between the motor winding star point and the supply neutral, will carry a current proportional to the unbalance voltage. This trip element can then be arranged to operate a switch which will isolate the motor from the supply when the unbalance (that is, the neutral current) reaches a dangerous level. "Single-phasing" caused by disconnection of one of the three-phase lines to a motor, produces a major unbalance and a corresponding quick response from the neutral overload unit and action of the isolating switch is initiated before burn-out of the motor can occur. Similarly, the motor winding is protected against earth faults and short-circuits which cause an unbalance in winding impedance. It is evident that the more serious the fault the greater will be the unbalance current in the neutral trip and the quicker will be isolation from the supply.

In practice the neutral trip element is incorporated in the motor starter as an addition to the three line overload elements and is arranged to operate the common trip bar, which in turn operates the line switch contacts. A fourth pole (connecting supply neutral to motor winding neutral via the neutral trip element) is also added to the triple pole line switch. Thus, when the trip bar operates, all four lines are broken and the motor is completely isolated from the supply if a fault should occur. The normal earthing of the machine is not interfered with in any way.

Overload protection is provided by the standard means of a line overload element in each line while "no volts on line" protection against complete supply failure is provided by the usual magnetic "no-volt trip." Thus, full protection against single-phasing, and graduated protection against winding earth faults and short-circuits, is achieved by the addition of a fourth pole and a trip element in the standard motor starter provided with no-volt and overload protection.

On the same stand we saw an electrically-operated linear actuator, in which the rotation of a ½ h.p., 2700 r.p.m. motor is converted by self-contained gearing into linear movement, the total travel of the output member being 8½in in thirty-five seconds, with a pull or thrust of 3000 lb. The linear movement is reversible, the motor being controlled by a reversing contactor, and over-travel in either direction is prevented by limit switches.

The output member is disposed below the driving motor, the direction of travel being parallel with the axis of the motor shaft, and the whole assembly forms a single unit with an integral baseplate.

Metal Industries, Ltd.

The electrical division of Metal Industries, Ltd., 60, Buckingham Palace Road, London, S.W.1, held a joint stand on which were shown some of the products of Brookhirst Switchgear, Ltd., Chester, Cantie Switches, Ltd., Bromborough, and Igranic Electric Company, Ltd., Bedford.

One of the exhibits was the new Igranic "SM" brake (Fig. 11) which has been produced to meet the demand for an equipment conforming to the A.I.S.E. requirements for brakes having standard wheels and fixing positions for the new

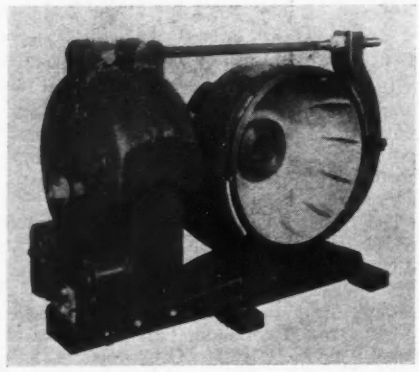


Fig. 11—"SM" electrically-operated brake—Igranic

"600" range of mill motors. In general design the "SM" brake resembles the "M" brake and is suitable for all mill and crane motors. Adaptor baseplates will be available to allow of the replacement of an "M" brake by an "SM" brake.

A typical "Minunit" cubicle switchboard was among the Cantie exhibits on this stand. The circuit breakers, switches, switch-fuses and other components of these switchboards are of standard dimensions, designed to fit into the various standard apertures formed by the steel channel sections that make up the framework. The switchboards themselves are built to meet the customer's requirements. To simplify maintenance the switches and switch-fuses are in most instances withdrawable as complete units from the front of the switchboard.

The Brookhirst display included a new mimic flow diagram control board designed for materials handling in installations such as iron ore works, chemical plant or gasworks. Basically, the diagram consists of a plastic sheet on which the plant layout is reproduced in schematic form. Indicating lamps, push-buttons and selector switches for the controlled drives are mounted in the flow lines of the diagram. Operation of an entire plant can be initiated at a centralised control board, and information about the conditions of material flow is given visually in the flow diagram. Another exhibit seen on this stand was a Brookhirst "549" cone-pivot voltage regulating relay for the control of transformer on-load tap-changing equipment and of the output voltage of mercury arc rectifiers. There was also a straight-on starter with plug-in interior to facilitate rapid replacement under fault conditions. This starter is designed for motors up to 7½ h.p., 400/440V, and can be arranged for local or remote control.

Astral Switchgear, Ltd.

The low-tension distribution equipment shown by Astral Switchgear, Ltd., Alma Road, Enfield, Middlesex, included one of the company's new products—a fuse-switch designed for B.S.88 high-rupturing-capacity fuses. This fuse switch is made in three ratings, 60A, 160A and 300A, the first of which is illustrated in Fig. 12. They have been short-circuit tested at 35MVA by

Fig. 12—60A fuse switch—Astral

K.E.M.A. Laboratories and subjected to load-making/load- breaking type tests to B.S.861. The housings are of cast aluminium with covers hinged at the lower end (as illustrated) and interlocked. The fuse switches are intended for unit or flush cubicle mounting and for each rating matching busbar chambers, cable sealing boxes, dividing boxes and reverse entry chambers are available.

Newman Industries, Ltd.

The prototype of a new range of vertical-shaft pump motors was one of the interesting exhibits shown by Newman Industries, Ltd., Yate, Bristol. They are squirrel-cage induction motors designed particularly for deep-well pump duty, and they are equipped with heavy thrust bearings. A non-reverse ratchet can be fitted optionally to protect the pump from damage resulting from accidental reversal of the motor or from "back-spin" caused by the static head of water draining back through the pump. The motors have cast iron frames, triple insulation, impregnated windings and dynamically balanced rotors. The complete range will cover outputs from

1½ h.p. to 125 h.p. and will be available both as totally enclosed motors and as splash-proof, weatherproof, fan-cooled motors, with either hollow or solid shafts. In their dimensions and electrical performance these machines are designed to comply with N.E.M.A. standards.

Londex, Ltd.

A new form of process and interval timer, designed for flush mounting on control panels, was shown by Londex, Ltd., 207, Anerley Road, London, S.E.20. It can be made to meet the requirements of all the normal switching actions and the time ranges are designed to cover most

Fig. 13—"RFT" process timer—Londex

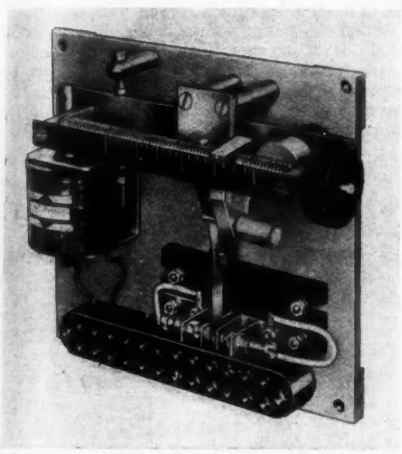


Fig. 14—"HS/C" calibrated relay—Londex

needs: the shortest is ten seconds with a dial graduated in $^1/_{10}$ seconds, and the longest is seventy-two hours, graduated in hours. The timer is driven by a self-starting synchronous motor which takes about 2VA from a.c. mains. On the face of the instrument immediately below the dial (Fig. 13) there is a setting knob; to the right of the setting knob there is a start button and, to the left, there is an aperture for an indicator lamp if required.

One of the new relays shown on this stand was a calibrated sensitive relay, the construction and general arrangement of which can be seen from Fig. 14. Among the high-speed counters exhibited was one receiving impulses from a mechanical or photo-electric source and displaying the count, at speeds up to 500 per second, on "Dekatron" tubes.

Johnson and Phillips, Ltd.

An exhibit designed to emphasise the advantages of cold-rolled steel for transformer laminations was shown by Johnson and Phillips, Ltd., Charlton, London, S.E.7. Compared with the hot rolling of steel for laminations, the cold rolling process offers the advantages of reduced iron loss and no-load current and the ability to work at higher flux density. The resulting improvement in weight, overall size and performance was exemplified by exhibiting two transformers, one of 100kVA, using hot rolled steel laminations, and another of 150kVA using cold rolled steel laminations.

Among the switchgear exhibits was one showing the use of a pole mounting "D" fuse switch and including a portion of a single-phase overhead line. The overhead line terminated on jumpers through h.t. drop-down fuses to a pole-mounted transformer for 15kVA, 11kV/250V.

Lancashire Dynamo Group

A "Silentvent" motor of 2000 h.p. at 2980 r.p.m., developed for high-speed drives such as boiler feed pumps, was shown by Lancashire Dynamo and Crypto, Ltd., Trafford Park, Manchester, 17. It is designed for quiet operation and high efficiency, the windage losses being reduced as far as possible. Cooling air is drawn

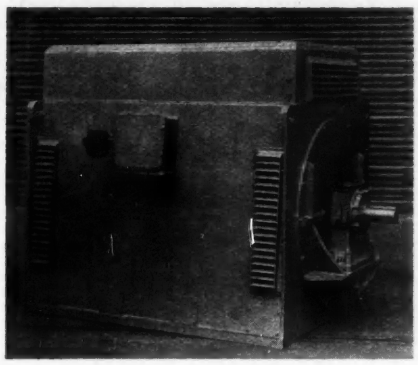


Fig. 15—"Silentvent" motor for quiet operation of high-speed drives—Lancashire Dynamo

through openings in the sides of the drip-proof enclosure (Fig. 15) by an axial-flow fan mounted at each end of the rotor, the fan blades being of aerofoil section to reduce noise and power loss. The air flow is towards the centre from the fan at each end and the discharge is in an axial direction through a louvred opening at the coupling end. This arrangement of the ventilation system avoids draughts in gangways and, since it avoids recirculation of the heated discharge air, adjacent motors can be mounted fairly closely side by side without loss of effective ventilation. Cooling of the rotor is entirely by air flow over its external surface and guide cones are fitted between each fan and the adjacent shrink ring, to reduce windage loss and noise. The shaft is carried in forced-oil-lubricated pedestal bearings, one of which can be seen in Fig. 15.

On the same stand there was shown, for the first time, the new "AA" (Anglo-American) range of motors, some of which are illustrated in Fig. 16. These three-phase, 50 c/s, squirrel-cage machines (both protected and totally enclosed, fan-cooled frames) have interchangeable outputs and dimensions. There is also complete interchangeability in outputs and fixing dimensions between the "AA" motors and the American new N.E.M.A. and the Canadian new C.E.M.A. protected and totally enclosed fan-cooled 60 c/s motors. The electrical performance is in accordance with B.S. 168 with class "A" insulation. The standard position of the terminal box is on the horizontal centre-line of the motor on the left-hand side of the frame, looking at the driving end. Cable outlets on the terminal box can be arranged in any one of four positions at 90 deg. intervals.

On the same stand Lancashire Dynamo Electronic Products, Ltd., Rugeley, Staffs, showed a variety of industrial electronic control equipments. They included two new products: first, a range of simple adjustable-speed drives in ratings from fractional horsepower to 2 h.p., and, secondly, a general-purpose photo-electric installation consisting of a photocell and light source.

Standard Telephones and Cables, Ltd.

Part of the display arranged by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2, was concerned with the company's rectifier equipment. It included a "Sen Ter Cet" CP7 equipment which is one of a range specially designed to provide d.c. power supplies in cathodic protection schemes for preventing corrosion in buried or submerged steel structures, such as harbour jetties, tanks and pipelines.

Another section of the stand showed heat treatment equipment, including a semi-automatic machine for the soft soldering of small armatures. It incorporates an air-cooled transformer with a rotary switch for selecting output voltages, which are low enough to ensure complete safety to operating personnel. The electrode holders are independently operated by double-acting air cylinders, each with its own speed control, pressure regulator and gauge. A holding jig supports an armature between centres and includes a ratchet mechanism for indexing the armature.

The same stand carried a display of "Stantelum" electrolytic capacitors, which are wide-limit capacitors having a space factor compatible with the working voltage. This property was illustrated in the exhibit which showed some six case sizes which could accommodate capacitances in the range 0·3 to 200 microfarads at working voltages between 150V and 6V. These capacitors employ tantalum electrodes and because of the inertness of this metal they do not deteriorate on shelf life.

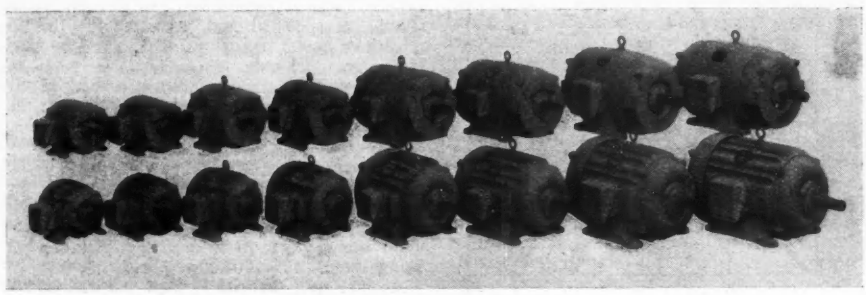


Fig. 16—Part of "AA" range of squirrel cage motors interchangeable with new N.E.M.A (U.S.) and new C.E.M.A (Canadian) motors—Lancashire Dynamo

Book of Reference

The "Gas Journal" Calendar and Directory, 1955. London: Walter King, Ltd., 11, Bolt Court, E.C.4. Price 25s.—The new edition of this reference book gives full up-to-date details of the composition of all the area gas boards and their various groups in this country, notes on British undertakings overseas, a members' list of the Institution of Gas Engineers, and particulars of other associations and kindred organisations. A useful reference section gives notes on gasworks practice, together with general information and tables of use to those working in the gas and allied industries.

Proving the Performance of Circuit-Breakers*

By J. CHRISTIE, M.I.Mech.E., M.I.E.E., H. LEYBURN, B.Sc. (Eng.), M.I.E.E., and J. F. BIRD, M.C., B.Sc., A.M.I.E.E.†

No. I

The characteristics of the main types of circuit breaker are briefly summarised, and the various aspects of test-circuit severity are considered, both in relation to actual service conditions and to their effects upon the different types of circuit breaker. Existing test procedures and methods are reviewed, and suggestions are made for the improvement of some of them and for their being brought more into line with present service requirements. Proposals are also made for methods of approach to certain tests which it has not yet been possible to standardise. Particular attention is paid throughout to the problems associated with the testing of large circuit breakers. Finally, a brief reference is made to the part played by field tests and the requirements of a modern testing station.

IT is essential that methods of test should be based as closely as possible upon service conditions. These fall under two main headings: short-circuit conditions, which are discussed in this section, and normal service conditions. The short-circuit conditions include a wide variety of breaking duties ranging from the rated breaking current down to the limited currents corresponding to remote faults; duties relating to making on to a fault and carrying through fault currents; duties involving breaking under conditions of loss of synchronism, auto-reclosing and others. The way in which these various duties are reflected in the basic circuit characteristics, namely, current, voltage, power factor and circuit configuration, which in combination determine the severity of testing, is discussed here.

Current.—The effects of symmetrical currents are reasonably straightforward and consistent.

Asymmetrical currents must be considered in relation to the power factor, which controls the degree of asymmetry and the rate of decrement, as illustrated in Fig. 1. It is worth noting

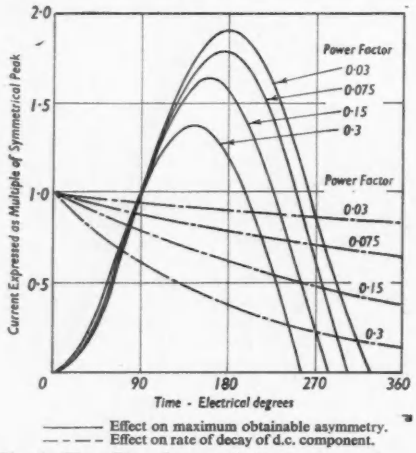


Fig. 1—The effect of power factor on the maximum obtainable current asymmetry and rate of decay of d.c. component

that the maximum d.c. component that it is possible to obtain at the first peak with a power factor of 0·15 (the lowest specified for short-circuit test in any standard specification) is 64 per cent, giving a peak current of $1{\cdot}64I$ in the first loop, where I is the peak value of the rated symmetrical short-circuit current. To obtain $1{\cdot}8I$, as required by B.S. 116 for the making-capacity test, the power factor must be reduced to about 0·075. Although this is below the normal values of power factor encountered in systems at full short-circuit currents, the current of $1{\cdot}8I$ thus obtained corresponds reasonably well with the making current in generator circuits during the sub-transient period and thus constitutes adequate proof of the making capacity of the circuit-breaker with the full sub-transient current.

It is unlikely that a circuit breaker in service will be called upon to break an asymmetrical short-circuit. The exceptions are ultra-high-speed circuit breakers (including many of those fitted with making-current releases) and those rare occasions when a circuit breaker opens on a developing fault. In this latter case it is even more rare for the full power to be present. The importance of the asymmetrical test should therefore not be overstressed, and there is a good case for replacing it by some other kind of duty.

For certain circuit breakers the asymmetrical test will still be required, and it is therefore important that it should be applied in a consistent manner.

The authors consider that the asymmetrical breaking test is inadequately defined in present testing specifications. Arising out of experience, particularly with oil circuit breakers, it is suggested that, in addition to specifying the current and the degree of asymmetry at contact separation as is done at present, it should also be stipulated that in at least one of the three breaks,

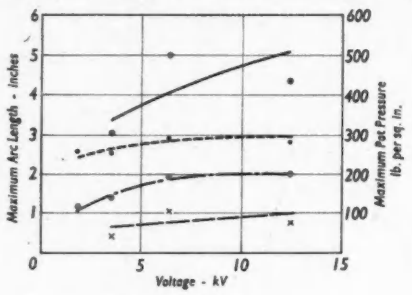


Fig. 2—Oil circuit breaker. Experimental curves showing the variation of performance with voltage in terms of arc length and pressure in an arc-control pot

constituting the duty cycle, arc-extinction must take place after a major loop and that in no case must the period of arcing be less than the normal period for the particular duty. It also appears necessary that the rate of d.c. decrement should be specified and, to cater for this, a maximum power factor of 0·075 should be used in asymmetrical tests.

Voltage.—The three significant aspects of the voltage relating to short-circuit breaking are the recovery voltage, the arc voltage, and the restriking voltage.

Recovery voltage.‡ In power systems, the recovery voltage is usually almost equal to the service voltage. To what extent a reduction is permissible in the test recovery voltage depends upon the characteristics of the circuit breaker being tested. This is discussed below.

Arc voltage. The arc voltage and current are a measure of the arc energy. With those circuit breakers in which the arc voltage tends to be high, the test voltage must not be reduced to such an extent that the arc voltage is limited. This has a bearing on the oil circuit breaker tests above 500MVA specified in B.S. 116, where provision is made for a reduction of test voltage on a sliding scale based on the limited outputs of existing testing stations.

Fig. 2 shows that arc length and pressure in an oil circuit breaker are not greatly affected by a reduction within limits of test voltage, but tests at reduced voltage do not prove the adequacy of clearances and the insulation security in the presence of arc products. It is therefore concluded that, although some reduction in test voltage is permissible with oil circuit breakers owing to their relatively low arc-voltage characteristics, such tests cannot be considered to be the equivalent of full-scale tests from every point of view.

With air-blast circuit breakers experience has shown that no appreciable reduction of test voltage can be permitted, and Fig. 3 shows how the performance of an air-blast circuit breaker varies with test voltage.

With air-break circuit breakers a reduction in test voltage is not permissible either, because their ability to clear short-circuit currents is associated fundamentally with high arc voltages.

Restriking Voltage.[1] The effect of restriking voltage is most often thought of in terms of r.r.r.v. This, of course, is only one aspect. Other equally important factors are the shape of the transient and its amplitude factor. It is becoming the practice to define restriking-voltage severity in terms of r.r.r.v. and amplitude.

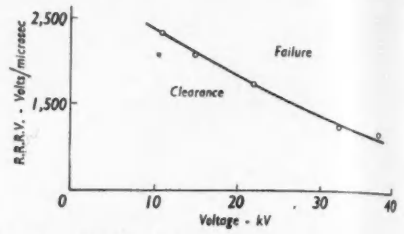


Fig. 3—Air-blast circuit breaker. Experimental curve showing the variation of performance with voltage in terms of r.r.r.v. at the point of failure

This is adequate for single-frequency transients. In service the restriking-voltage transients can be quite complicated. They may be a simple exponential, a single-frequency or a complicated multi-frequency.

Where the testing transient is single frequency (or with only minor higher-frequency components) the only safe method is to have a testing transient which is at all times greater than the service transient. If a circuit breaker is satisfactory when tested in this way there will be no doubt of its being satisfactory in service.

When the testing transient is multi-frequency, which is sometimes unavoidable, if the same method is followed an undue stress may be imposed upon the circuit breaker. This would be the case when the initial r.r.r.v. was high for a short period. Methods have therefore been

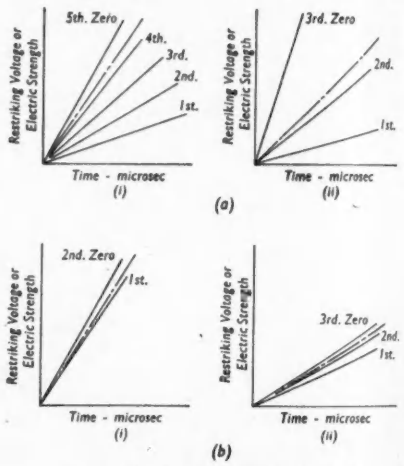


Fig. 4—Simplified diagram illustrating the effect of r.r.r.v. on arc duration in oil and air-blast circuit breakers

evolved to arrive at an equivalent single-frequency transient (or an equivalent r.r.r.v.), which can be used as a measure of its severity. The most notable of these is that produced by the A.S.T.A.[2] Whilst at the best such a method can only be approximate, experience in working with it appears to have been satisfactory so far.

An assessment of the effects of the restriking-voltage transient on different types of circuit breaker is useful to the testing engineer. These effects are not the same for air-blast circuit

* Abstract of paper "Proving the Performance of Circuit Breakers with Particular Reference to those of Large Breaking Capacity." Institution of Electrical Engineers, London, March 23, 1955.

† The authors are with A. Reyrolle and Co., Ltd.

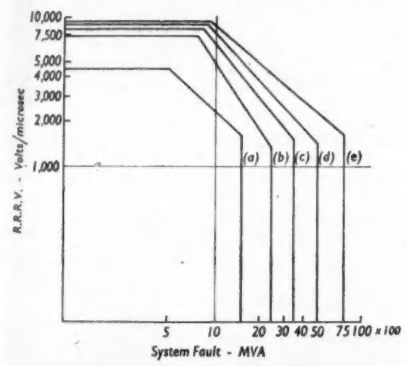
‡ It is suggested that the voltage appearing across the first break to clear in a three phase circuit breaker, which, in a system with the neutral earthed and the fault clear of earth, may be as high as $1{\cdot}5V/\sqrt{3}$ (where V is the system voltage), should be known as "the momentary recovery voltage."

breakers and oil circuit breakers, and the difference is illustrated in the much simplified curves of Fig. 4. In this figure the r.r.r.v. across the circuit breaker contacts is compared with the rate of rise of electric strength at consecutive current zeros. With air-blast circuit breakers, in which the arc-extinguishing medium is supplied from an external source, the rate of rise of electric strength can increase only slightly (with build-up of pressure) as the arc continues. A small change in r.r.r.v. can therefore be critical as between success and failure. In the case of oil circuit breakers in which the arc-extinguishing effects rise rapidly as the arc is lengthened, the rate of rise of electric strength increases proportionally at each current zero. A small change in r.r.r.v. is then likely to affect the arc duration by only a single loop one way or the other. Whether at large currents a further loop of arcing can be permitted will depend largely on mechanical considerations.

In the past, the absence of standard values of r.r.r.v. for testing has meant that, in many cases, individual consideration has had to be given to them. In certain instances excessive values of r.r.r.v. have been specified. The need for standardisation here, based on realistic system conditions, is very great, and a considerable amount of work has been done in various places to assess the values which may occur. A large number of conditions have been calculated relating to systems of various sizes between 66kV and 275kV.

Some of the curves showing the maximum r.r.r.v. which can be obtained on such systems under practical operating conditions are shown in Fig. 5. These curves are applicable mainly to power stations or other locations where the major power in-feed is through transformers. For other locations where the major in-feed is through lines or cables the r.r.r.v. is likely to be much lower.

It will be noted that the r.r.r.v. corresponding to the full short-circuit MVA of the system is



(*a*) 66kV systems. (*d*) 220kV systems.
(*b*) 110kV systems. (*e*) 275kV systems.
(*c*) 132kV systems.

Fig. 5—Envelope curves showing the maximum values of r.r.r.v. which are liable to occur under practical conditions with different values of system fault power

almost constant, irrespective of voltage, and that there is similarly comparatively little difference between the highest values of r.r.r.v. obtainable, except at 66kV.

On the basis of these calculated curves it has been possible to arrive at a set of values of r.r.r.v. corresponding to the different standard test duties, which might reasonably be taken as standard. These are given in Table I.

It will be noted that the values proposed for the 30 per cent ratings are lower than the maximum values shown in the curves. It should, however, be noted that most of the knee points in this region occur at less than 30 per cent, e.g. 8800V per microsec on the 275kV curve occurs at 880MVA, which is about 12 per cent, and from this point of view alone the choice of the lower value of 7000V per microsec is justified.

TABLE I

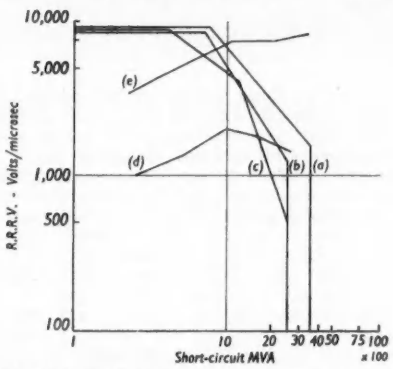
Service voltage	R.R.R.V. at the given percentages of rated breaking capacity		
	30 per cent	60 per cent	100 per cent
kV	V/μs	V/μs	V/μs
66	5000	2500	1500
110	7000	2500	1500
132	7000	2500	1500
220	7000	2500	1500
275	7000	2500	1500

At testing stations it is usually possible at the higher short-circuit MVA to produce restriking-voltage severities in excess of those met with in service. At the lower MVA this is not so, and recourse has sometimes to be had to unit tests in order to increase the r.r.r.v. A typical example of the values which can be obtained and the relation they have to service conditions is given in Fig. 6.

A study of published information relating to service conditions indicates that the amplitude factor usually lies between 1·2 and 1·8.

Likewise for testing stations it has been shown[5] that the natural amplitude factors fall in much the same range with a tendency towards a minimum of about 1·4 in those circuits which give single-frequency restriking-voltage transients. Standardisation of the amplitude factor based on system conditions is desirable.

Power Factor.—The effect of the power factor on asymmetry has already been dealt with. It only remains to note that the power factor also decides the instantaneous voltage at current zero and therefore has a marked effect on the amplitude of the restriking voltage. When the power factor is high the reduction in amplitude of the restriking voltage can be considerable.



(*a*) Calculated characteristic for representative systems with 3500MVA maximum fault capacity.
(*b*) Calculated characteristic for representative systems with 2500MVA maximum fault capacity.
(*c*) Calculated characteristic for the British Grid system.
(*d*) R.R.R.V. obtainable at all British testing stations[4 6] not using unit tests.
(*e*) R.R.R.V. obtainable at a typical testing station using unit tests on one unit of a four-break circuit breaker rated at 3500MVA.

Fig. 6—Envelope curves for 132kV showing the comparison between values of maximum r.r.r.v. calculated for representative systems and those calculated for the British Grid system, together with values available at testing stations

Circuit Configuration.—The configuration of the circuit can influence the circuit breaker under test in a variety of ways as follows :—

(*a*) The physical arrangement of the external connections to open-type circuit breakers can affect the electromagnetic forces which may act upon the arc.

(*b*) In multi-break, open-type circuit breakers the proximity of earthed screens or walls can affect the voltage distribution.

(*c*) The series or parallel connection of the resistance and the reactance critically affects the restriking voltage transient.

(*d*) The position of the current-limiting impedance and the position of the earth in the test circuit may determine the voltage stressing of the circuit breaker during the breaking process.

(*e*) Where a circuit breaker is of non-symmetrical construction (usually the case with single-break circuit breakers) the way in which it is connected in circuit may influence its performance.

Care must be taken to ensure that the circuit arrangements are in accordance with service conditions.

Methods of Test Under Short-Circuit Conditions

There is little difficulty in reproducing all the short-circuit conditions discussed in the previous section at most modern testing stations for circuit breakers rated up to, say, 750MVA. There is usually only one exception, namely, the reproduction of the high r.r.r.v. associated with fault values corresponding to 30 per cent or less of the rated breaking capacity. This can usually be overcome by a knowledge of the characteristics of the circuit breaker under test in this region, and experience in service indicates that such a solution is satisfactory.

With large circuit breakers, however, namely those rated in excess of 750MVA, there is an economic problem ; the building of testing stations to prove, by means of full-scale tests, circuit breakers rated at, say, 275kV, 7500MVA, is prohibitive, and means must therefore be found to prove them by other than full-scale tests, e.g. by single-phase tests, unit tests or synthetic tests.

Although most of the following subsections are applicable to all circuit breakers, the emphasis in many of them is upon the testing of large circuit breakers, and those dealing with single-phase, unit and synthetic tests apply to large e.h.v. circuit breakers only.

Single-Phase Testing.—The economic advantage of proving large high-voltage circuit breakers by single-phase tests is obvious and need not be enlarged upon. Such testing is justified where the poles of a breaker are separate and where the mechanical operation is independent of whether or not fault current flows in all phases. This can be checked by three-phase full-current tests at low voltage. Two points only need then be considered when relating single-phase tests to the corresponding three-phase tests.

The first is that in a single-phase test the duration of the final loop of current is determined solely by the degree of asymmetry. In a three-phase test, however, when the first phase has cleared, a change of phase occurs in the current flowing in the two other phases. This results in a shortening of the current loop in one phase and a lengthening in the other. The main practical importance of this is felt only when it occurs at the same time as a high degree of asymmetry. Compensation can be made in single-phase tests where this is thought to be necessary, but in the authors' experience it can generally be ignored.

The other problem is to determine which test voltage is correct. The value given in the international specification, I.E.C. 56, and in B.S. 116 is $1 \cdot 5V/\sqrt{3}$, where V is the system voltage. This value (the momentary recovery voltage, see footnote on page 424) is based on a three-phase fault to earth in a non-effectively earthed system or a three-phase fault clear of earth in any system irrespective of the method of earthing. While in the authors' opinion a good case can be made for a reduction of the factor of 1·5 for any system, this is of little practical importance with systems whose neutral point is earthed through a resistance or reactance or is insulated, i.e. mainly at the lower voltages. At the very high voltages, however, it is quite another matter. Here, effectively earthed systems are becoming more and more accepted, while the possibility of a three-phase fault clear of earth on a high-voltage line, equipped with earth wires, is remote. The chance that such a fault might occur with full MVA is so much more remote that it could reasonably be neglected. It is useful, therefore, to study the conditions which may exist on an effectively earthed system. This has been defined, in effect, as a system in which the maximum r.m.s. voltage to earth which can exist on a sound phase when there is an earth fault on one of the other phases is $0 \cdot 8V$. It follows from this that the maximum recovery voltage which may appear momentarily across the break of a circuit breaker is also $0 \cdot 8V$ or $1 \cdot 38V/\sqrt{3}$. This may occur on the second phase to clear in the event of a three-phase fault to earth.

There are, however, other items which must be taken into account in assessing the severity of duty on the circuit breaker. The most important of these is that the momentary recovery voltage in an interruption involving more than one phase is normally of very short duration, being greater than the peak phase-neutral voltage for a few milliseconds only after arc extinction. The voltage then falls and the steady phase-to-neutral value of the recovery voltage will nearly always be established before the next peak occurs. To maintain a high recovery voltage in single-phase testing is thus unnecessarily severe.

It is impossible to make an accurate assessment

of all these effects, but the authors believe that there may well be considerable justification in the case of circuit breakers intended for use on effectively earthed systems for making single-phase tests at the 100 per cent duty at $V/\sqrt{3}$, or possibly at a compromise value of $1{\cdot}2V/\sqrt{3}$, leaving the lower test duties to be done as hitherto at $1{\cdot}5V/\sqrt{3}$. The general concensus of opinion in America and a large body of Continental opinion appears to favour a reduction of the factor $1{\cdot}5$.[5 9 10 11]

Unit Testing.[7 8]—Even if advantage is taken of single-phase tests, it is still economically impossible to make anything like full-scale tests on some of the largest circuit breakers.

Although experience with unit tests applied to large multi-break circuit breakers is still somewhat limited, they are proving very satisfactory, provided that adequate precautions are taken. This involves preliminary testing to determine such matters as :

(*a*) Voltage distribution across the breaks (so that the correct unit test voltage can be assessed).

(*b*) Independence of the circuit breaker to stray electric fields (which may be brought about by capacitance grading or resistance grading).

(*c*) Independence of the circuit breaker to post-arc current effects.

(*d*) Uniformity of performance of individual units.

(*e*) Absence of interference between breaks.

(*f*) Effect of contamination of external insulation.

It is understood that rules for the making of unit tests are in course of preparation by the A.S.T.A. and will soon be in force. It is not wished to anticipate these in any way, but it is apparent that much of the validity of unit tests will depend on satisfactory measurement of voltage distribution and the ability to demonstrate that this is unimpaired by the arc and post-arc conductivity effects.

The determination of the static voltage distribution is largely a matter for the laboratory, and several methods are employed. Preliminary determinations by models immersed in electrolytic tanks have been found to give a useful guide for further tests.

Other measurements involve the application of 50 c/s and impulse voltages under a wide variety of conditions in which the configuration of conductors, the proximity effect of earthed screens and the point of application of the earth are taken into account.

From the various tests which must be made as indicated, the unit test voltage will be derived. However accurately this may be done, it is apparent that its validity will be doubtful unless it can be shown that the voltage distribution is substantially unimpaired during the time the circuit breaker is interrupting the short-circuit current. There are two periods involved, and the distribution of voltage should be measured in both : first, there is the arcing period, and the distribution of arc voltage will be a measure of the distribution of duty between the breaks ; secondly, there is the recovery voltage distribution and this is an indication of the distribution of severity.

The measurements are best made with full current and the highest obtainable voltage and simultaneously on as many breaks as is possible. Complications are introduced since the voltage dividers and leads to the cathode-ray oscillograph may affect the voltage distribution, and care must be taken to ensure that if they do so due allowance is made.

It should be noted that when making unit tests the r.r.r.v. is reduced in proportion to the unit test voltage. This is of great help when tests are being made at outputs where the test plant r.r.r.v. is lower than in service. This applies particularly at the lower outputs (see section " Restriking Voltage ").

On the subject of unit testing, mention may be made of the method of connection in which a three-phase supply is applied to the single pole of a multi-break circuit breaker, one of the phases, for example, being connected to the common point and the two others to the outer points.[20] Since there is a phase displacement between the currents in the adjacent breaks, it is a matter for speculation how far this method is valid when applied to breaks contained in a common enclosure unless they can be proved to function independently of each other. However, where the breaks are independent the method is comparable with unit testing.

Unit tests are now being widely used, and the technique of making them is being improved. In the authors' opinion, unit testing, together with single-phase testing, will provide the main basis for proving large circuit breakers for some years to come.

Synthetic Testing.[12]—The number of synthetic testing schemes which have been proposed is large, but there are only three main types. In the first, the current and recovery voltage are provided from different sources. In the opinion of the authors the best method in this group is illustrated in Fig. 7.[15 16] Here the current is

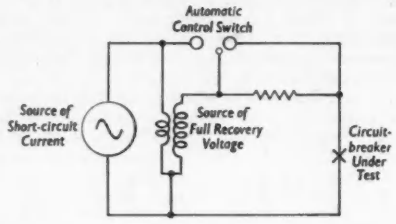


Fig. 7—Circuit for two-source type of synthetic test

provided by a lower voltage source, and the full recovery voltage is automatically applied at every current zero by a switching device. The main objections to this scheme appear to lie in a tendency to prolong the current-zero pause, and a possible limitation of the arc voltage.

The second group consists of a device for charging a condenser from a low-power source and then discharging it, usually with a 50 c/s oscillation,[17] through the circuit breaker under test. The authors have not had the opportunity of studying this method at first hand, but it would seem to offer very little saving in capital cost if carried to its logical conclusion.

The third group consists in testing a scale model and extrapolating the results.

None of the three methods mentioned are, as yet, suitable for formal proving of circuit breakers, but valuable information may be obtained from any of them in the course of research and development.

Selection of Test Duties.—The present specification requires that tests be made at 10, 30, 60 and 100 per cent of the rated symmetrical breaking capacity within limits of ± 20 per cent of these values, except for 100 per cent. In order to get the best output from a test plant at any particular voltage when testing large circuit breakers it may be desirable to have a rather more flexible test schedule, and it is suggested that the 30 and 60 per cent duties be replaced by two duties to be made at any value between 30 and 80 per cent provided that the difference

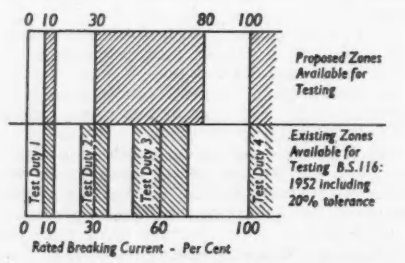


Fig. 8—Diagram showing the effect of the proposed change in test duties 2 and 3

between them is not less than 25 per cent and not more than 50 per cent of the rating. Fig. 8 illustrates the effect of this.

Making Tests.—The problem of making on to short-circuit currents is principally mechanical, and such tests are in the main a check on the strength of the contacts, the mechanism and the general structure. For the making duty, circuit breakers are divided into two broad categories : those that close fully home and latch, and those that do not. It is required that those that do not latch shall be trip-free.

The main application for non-latching circuit breakers is at the lower voltages where heavy short-circuit currents may make latching uneconomical. In this case, the provision of an automatic instantaneous tripping feature (mechanical or electrical) as part of the circuit breaker is the usual practice. It is essential in testing to prove that such a feature operates correctly under short-circuit conditions.

Circuit breakers which are intended to close and latch must be shown to be capable of doing so. It is fairly common practice to make such circuit breakers trip-free to some extent ; for example, during the latter part of the stroke. The operation of this feature can best be proved in a make-break duty.

On the electrical side the extent and effects of the arcing before the contacts touch must be checked. This can be done completely only if tests are made with full voltage and current. If made single phase, the test voltage should be $V/\sqrt{3}$. If tests are made with reduced voltage, it may be desirable to simulate the effect of the full-voltage arcing by means of a piece of fine fuse wire of appropriate length attached to the fixed contacts. This presents no difficulty where the making contacts are external, but it is difficult when they are internal and perhaps immersed in oil. In that event the synthetic test circuit of the two-source type mentioned above and illustrated in Fig. 7 may be used. It would appear to have no such limitations for making tests as it has for breaking tests.

Short-Time Current-Carrying Tests.—The mechanical effects associated with short-time currents are to some extent covered by the making-current tests. But troubles such as contact chatter and thermal effects, or a combination of mechanical and thermal effects, can occur during the period of short-time current flow (1–3 seconds), which might not be noticeable in a making-current test.

Test voltage plays virtually no part in these tests, and it is therefore permissible to make them at the lowest convenient voltage. In this way it is possible to keep the current decrement as low as possible, and this enhances the value of the tests.

(To be concluded)

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Forging Manipulator

THE first forging manipulator built by the Head Wrightson Machine Company, Ltd., under its licence arrangement with the Salem-Brosius Incorporated, was recently completed at the company's Middlesbrough works. The new machine is designed to handle billets from 6in to 24in square and weighing up to 2000 lb when the centre of gravity of the load is not more than 10ft from the centre line of the front wheels.

The general design of the manipulator can be seen in the photograph reproduced here showing it undergoing tests in the maker's works. It has a welded steel chassis supported through heavy coil springs on two widely spaced wheels at the front and a central steering and driving wheel assembly at the rear. The machine operates on a 200V, a.c., electric supply which is taken from an overhead cable, on a take-up reel, through a slip ring assembly at the head of a tubular mast at the rear. A 10 h.p. motor driving a Hele-Shaw variable volume pump supplies hydraulic power to the double-acting cylinders which actuate the steering, lifting, tilting, gripping and lateral shifting motions of the tong head assembly.

The tong head is mounted on a large diameter shaft supported in a heavy cast steel housing, and the tong jaws are opened and closed by a hydraulic cylinder at the rear. The tong housing is supported by links on two cross shafts in the frame of the machine. In its housing the tong shaft can be rotated continuously or intermittently in either direction by a hydraulic motor coupled to a reduction gear unit mounted on the top of the housing. A double-acting hydraulic cylinder situated centrally below the frame is connected to the tong link assembly and actuates the links to raise or lower the tongs vertically. Another hydraulic cylinder set vertically in a bracket structure behind the tongs is used to tilt the tongs. The maximum downwards tilting angle is sufficient to enable the tongs to pick up billets from floor level when necessary.

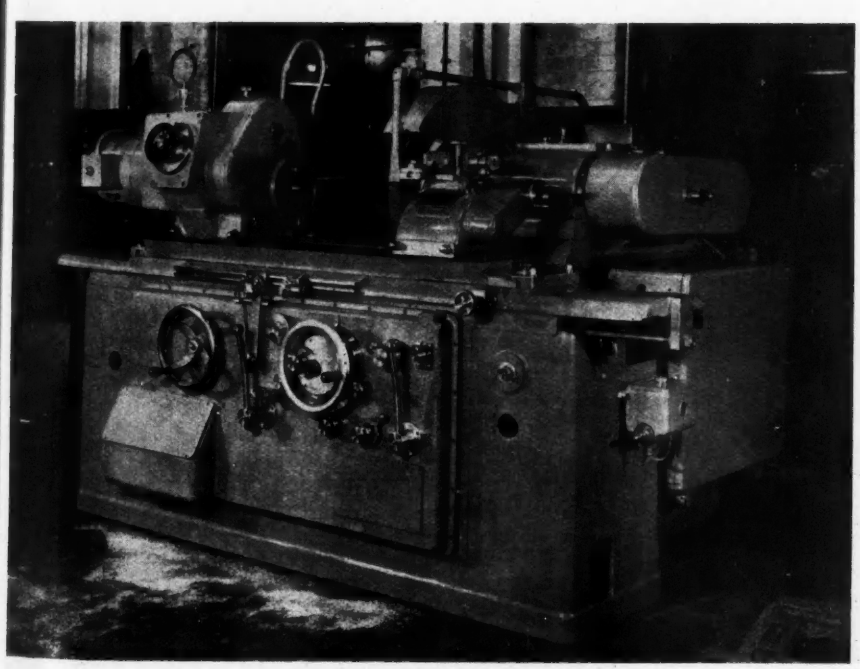
As already mentioned, the complete tong assembly is carried on two cross shafts, and on these shafts it has a lateral movement up to 6in on each side of the centre line of the machine under the control of a double-acting cylinder mounted on the side frame. With this sideways movement of the tongs the operation of positioning of a billet between the dies is considerably speeded as it eliminates necessity for manœuvring the complete machine to set the work precisely in line with the die openings.

The rear wheels of the machine are driven by an electric motor and they can be turned up to 90 deg. each way. Steering is effected by a hydraulic cylinder which actuates a pinion and ratchet quadrant and is controlled by an operator's handwheel. This handwheel is quite small and no undue effort is called for even when turning the wheels with the machine stationary. An indicator is set in the floor near the operator's feet to show the setting of the steering, so that when first mounting the machine he can be sure of the direction in which it will travel before engaging the drive. An electromagnetic brake attached to the driving motor is automatically applied when the motor is stopped.

A line of control levers for the various motions is conveniently arranged on a manifold in front of the driver's position and each lever incorporates a locking button which must be depressed before the lever can be moved. From his raised seat the operator has a clear view of the tongs in all positions, whilst he is sufficiently far from the front of the machine to avoid undue discomfort from the heat radiated from the hot billet.

We are informed by the company that machines of this design can be made with capacities up to 20,000 lb and arranged for drive from a mains electric supply or with a self-contained diesel engine drive.

2000 lb capacity forging manipulator with electric drive and hydraulically operated steering, lifting, tilting, gripping and lateral shifting motions



Redesigned hydraulic cylindrical grinding machine

Hydraulic Cylindrical Grinding Machine

THE "Type L" hydraulic cylindrical grinding machine made by the Newall Engineering Company, Ltd., has recently been redesigned to increase its capacity and extend its field of application. This new machine has been redesignated the Newall-Keighley "L" grinder and its production has been transferred to the works of Keighley Grinders (M.T.), Ltd., at Keighley. It is being made in four sizes to take work 24in, 36in, 48in and 60in between centres and swings up to 12in instead of 10in as in the original design.

The new machine can be seen in the accompanying illustration. It has a redesigned base to improve rigidity in the centre and the ribbing under the wheelhead has been increased to provide the maximum possible support. By extending the bottom table the ways are provided with a permanent cover to prevent the ingress of dust and grit. The top table width has also been increased to 8in to give added support for the workhead and tailstock.

To accommodate the wheelhead motor, which, as can be seen, is now mounted on the wheelhead itself, the underslide area and length have been increased. By the fitting of a sub-slide the wheelhead can now be positioned for the grinding of acute angles when using the dead and live centre workhead with a swivelling base. The wheelhead assembly incorporates an anti-backlash device and an anti-backlash cylinder on the withdraw unit eliminates backlash without reducing pressure on the sizing face of the withdraw cylinder. The wheelhead trip gear is fully hydraulic and does not incorporate any springs or catches.

To facilitate operation a number of modifications have been made in the controls. A universal reverse lever has a plunger which can be withdrawn to clear the table dogs and, if required, an automatic wheel wear compensating device can be incorporated in the feed wheel. No locking bolts are fitted between the handwheel and dial handwheel and plunge feed gear, and interlock and reverse interlock are available without the use of mechanical linkage.

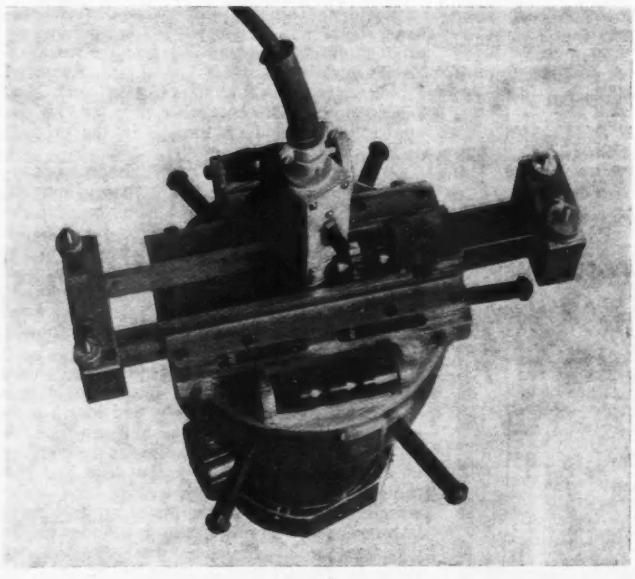
Portable Flange Facing Machine

WHEN it is required to face damaged flanges on large pipes, valves and similar installations in industrial establishments or on board ship much time can be lost and difficulties experienced in dismantling and transporting sections or parts to suitably equipped machine shops. To obviate this loss of time and the trouble involved, a portable flange facing machine has been developed by David Reekie and Sons, Ltd., 93, Hope Street, Glasgow. This machine can be taken to an installation and used to face the flanges *in situ*, irrespective of the angle at which they are set and without need for disturbing adjacent plant.

The machine, shown in the accompanying illustration, has a high tensile cast aluminium bronze gearcase on the lower part of which is a flange-mounted ½ h.p. totally enclosed, fan-cooled, a.c. motor. A rotating head assembly on top of the gearcase is driven through the gearing at a constant speed of 21 r.p.m. A central column, through which the power leads to the motor pass, is fitted with the operator's control switch and remains stationary whilst the head rotates. A rigid slideway for a radial arm is fitted in a carrier bolted on to the head and has at one end a holder for the cutting tool. Means of micro-feed through a knurled knob are incorporated in the tool-holder for adjusting the depth of cut.

Through a nut in the tool-holder block the radial arm is connected to a feed screw and a toothed wheel is keyed on to the inner end of this feed screw. As the head rotates this wheel is contacted at each revolution by a pin on the fixed central column of the machine. By the pin contacting the toothed wheel in this way the feed screw is turned to move the radial arm in its slide and feed the tool across the flange face by a predetermined amount at each revolution.

When it is required to locate the machine in the bore of a flange the radial arm is positioned centrally. A special bridge piece with two spaced pads in its lower face is then set on the free end of the arm and a third pad is screwed down in the tool-holder. The machine is then picked up by its two handles and lowered, motor first, into the bore until the three pads contact the flange face. Six screws spaced round the circumference of the gearcase are then screwed outwards until the machine is rigidly held in a central position in the bore. On the bridge piece being removed and the tool-holder pad retracted the radial arm can quickly be adjusted in its slide to place the tool in position ready for the machining operation.



Portable flange facing machine for flanges from 11½in. to 22½in. diameter

The machine can be used in bores from 11½in to 16in diameter and has an effective facing capacity for flanges from 11½in to 22½in diameter. When it is required to machine a tapered face on a flange, the carrier slideway can be packed up at one end with slips of the necessary thickness.

For use in cases where a scroll finish is needed on a flange an attachment consisting of a special slideway carrier and radial arm with a constant feed drive can be fitted on the machine. In this attachment a mitre gear driven through a clutch actuates the lead screw continuously as the head rotates. A mechanical stopping device is fitted to disengage the feed when the radial arm extends a predetermined distance. With this mechanism scroll finishes of 0·070in pitch and 0·020in deep can be machined.

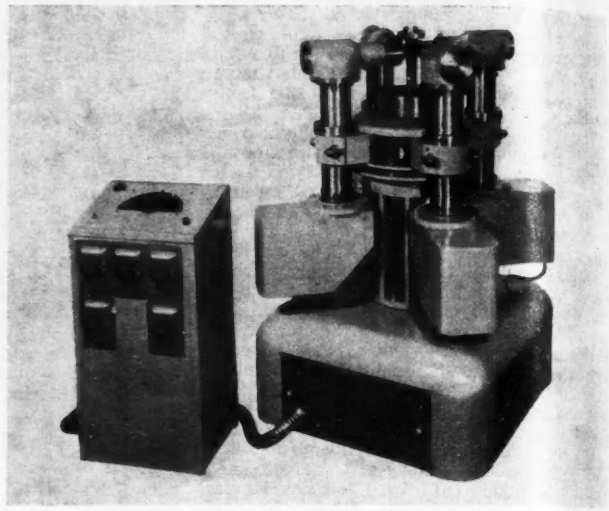
We are informed by the makers that machines of this design can be supplied with an air motor instead of electric motor drive and they weigh much less than the 132 lb of the machine described. It is also proposed to put into production two machines of smaller size for facing flanges on work from 3in to 6in bore and 7in to 10in bore respectively. These machines will be driven by external means and the motor will not have to be lowered into the bore.

De-burring Machine for Gears

A MACHINE for removing automatically the burrs left on the teeth of gear wheels in cutting has been developed by the Elgro Machine Tool Company, Ltd., a subsidiary company of Gem Brushes (Luson), Ltd., Minerva Road, Park Royal, London. On this machine the burrs are removed by rotating wire brushes, and, if required, it can be set to impart a radius on the edges of the teeth. It is suitable for use with all forms of gears up to 2ft diameter.

The machine, as can be seen from the accompanying illustration, consists of a substantial cabinet base with a central column assembly supported on pillars. A heavy annular way near the head of the column has a tee-slot machined round its circumference and rigid brackets, supported from and adjustable round this way, carry the wire brush de-burring units. Each de-burring unit consists of a tubular column with a ¾ h.p. motor at the bottom driving the wire brush spindle at the top of the column. This drive is transmitted through vee belts and a vertical shaft and by changing the belt pulleys the spindle speeds can be adjusted to suit the material from which the gears are made.

The gear to be de-burred is placed on a mandrel on the top of a central spindle extending above the wire brushes. Here the gear is located with its teeth in respect to the brushes by a hinged latch of the appropriate profile. The gear wheel is then locked on the mandrel by three plungers which are automatically projected out of recesses as the mandrel is lowered by a hydraulic cylinder in the base of the machine. A heavy spring imparts a load on the plungers and the lowering of the mandrel brings the burred edge of the gear into the brushing position. The mandrel is mounted on a central oscillating spindle driven through differential gearing from a motor in the base of the machine.



Gear de-burring machine with rotary wire brush heads

As the spindle rotates it feeds the gear teeth in turn into the wire brushes and, through the differential gearing it advances the gear one tooth in each complete revolution. The number of tooth indexing movements effected on each machine cycle is predetermined by the setting of a pointer on the control cabinet at the side of the machine. Up to twenty-five oscillations or indexing movements can be completed in each machine cycle. At the end of the preset cycle the gear is automatically lifted clear of the brushes. The turning movement imparted to the gear as it oscillates ensures that the wire brushes de-burr the whole of each tooth profile.

The machine illustrated has four brush heads, but more can be fitted if required, or, if necessary, any of the heads can be swung round to an inoperative position. By using a number of heads each can be arranged to clean the teeth round part of the circumference of a gear, and thus reduce the total machining time. Alternatively, one brush head can be used to remove the worst of the burr and the next head to impart a finished radius. For each size and type of gear handled the machine can be fitted with an appropriate mandrel and differential gear oscillating assembly.

Articulated Tipping Gear

LAST week we saw demonstrated the link tipping gear which is made by Telehoist, Ltd., Telehoist Works, Swindon Lane, Cheltenham. It was shown in operation at a road works in Gloucester and was mounted on a Thornycroft "Big Ben" chassis which has a total chassis weight of 17,400 lb and a gross laden weight of 50,000 lb, the engine being a Thornycroft diesel engine of 155 maximum brake horsepower. The articulation of this gear and the orientation of the rams is shown in our illustration.

This gear has been specially designed for the heavier range of six-wheel, short wheelbase chassis. It will give an extra angle of tip which is useful for rock dumping with a scow-ended body, and is powerful enough to deal with the heavy loads with which these chassis deal on excavating work. The angle of tip is 70 deg. The gear has an exceptionally fast tipping and return action which is at all times under the full control of the operator.

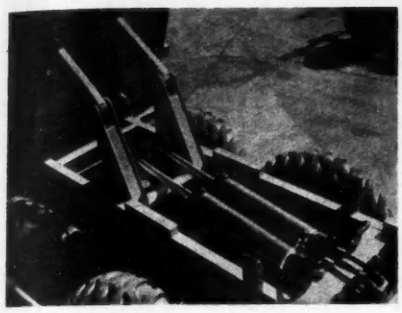
Double-acting rams are fitted and the whole tipping unit is self-contained so that no tipping stresses are imposed on the chassis. During the demonstration a load of approximately 18 tons

was tipped in twelve seconds. The tipping body weighs a further 3½ tons.

The single-stroke rams are mounted in twin formation. The main tube is 6½in diameter inside and the bore is accurately honed. The piston rod is plated and all bearing surfaces are bronze. Seals and bearings are easily renewable in the event of wear.

The linkage is designed to give a generous angle of tip with a relatively short ram travel. It consists of a pair of thrust arms hinged to the body sub-frame at the top and to a pair of bell crank links hinged to the lower sub-frame at the bottom. The links are substantially fabricated of box section to give maximum rigidity. To the bottom links is attached a cross member which carries brackets forming the top attachment to the rams.

The sub-frame consists of a pair of 6in by 3in channels mounted on top of the chassis. The rear has bosses built into it to take a 2in shaft

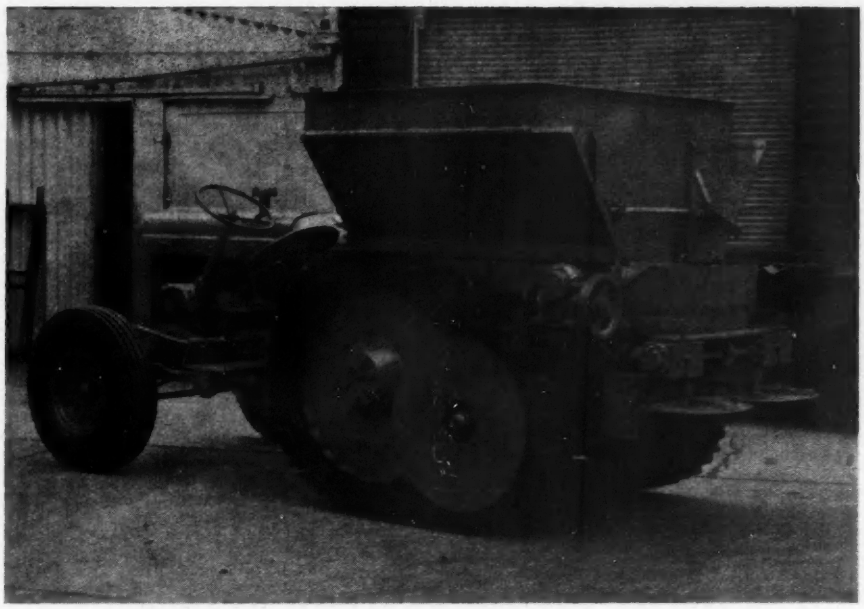


Articulated tipping gear, showing sub-frame, rams and linkage

on which the body tipping hinges pivot, and near the centre is a pivot for the link gear. Across the front of the sub-frame is a strong member to take the thrust from the lower end of the rams. This sub-frame takes all the stresses due to tipping and none are transmitted to the chassis.

A large output pump is fitted, mounted on a cradle attached to the chassis. It is driven by a universally jointed shaft from a power take-off bolted to the side of the gearbox. The control for the power take-off is operated from the driver's cab. An oil reservoir with a capacity of approximately 19 gallons is fitted either on the side of the chassis or in between the chassis frame, according to space available, and bolted to the top of the tank is an overload valve.

A piston type control valve is fitted in a convenient position near the oil reservoir and has an extension through to the cab to allow it to be operated by the driver. All main delivery pipes are 1in O.D. solid drawn steel tube with flared connections. To allow for movement of the ram the pipes to either end are flexible.



Lime spreader mounted on diesel engined tractor, fitted with half tracks and 9·00 × 16 pneumatic tyred front wheels. The width of spread is from 20ft to 25ft

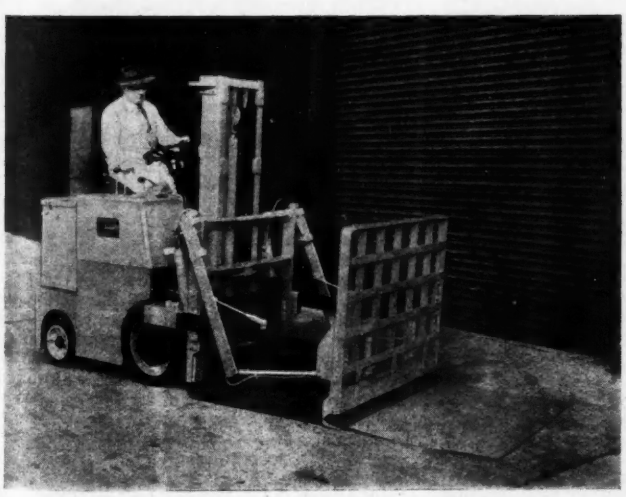
Fork Truck Stacking Attachment

In the employment of a fork truck system of mechanised handling for unit loads made up of such articles as boxes or cartons, a large proportion of the capital outlay is required for the purchase and subsequent maintenance of pallets. For this reason Conveyancer Fork Trucks, Ltd., Liverpool Road, Warrington, recently introduced a new attachment known as the "Skid-Stac" which is designed to replace the conventional pallet with a sheet of cheap fibreboard which can be regarded as expendable. This attachment can be seen in the accompanying illustration fitted to one of the firm's 3000 lb capacity battery-driven trucks.

The forks normally fitted to the truck are replaced by a steel load carrying plate with a polished surface. Mounted above this plate and supported by a pair of sliding arms, is a rectangular steel frame which is moved across the plate by a system of levers actuated by twin hydraulic cylinders. A slot is formed along the full width at the bottom of the frame and a gripper blade in this slot is operated by a small pair of hydraulic cylinders. The operation of these gripping cylinders is automatically controlled through a sequence valve so that when a selector is put into the "pull" position the gripper blade descends and the frame is drawn back from its extended position across the plate. When the selector is put in the "push" position the gripper blade rises and the frame then automatically moves forward across the plate.

When using the attachment, cartons or boxes are stacked on a sheet of fibreboard and the truck is driven up to the stack with the frame extended, as shown in the illustration, so that the edge of the board can be introduced into the slot in the frame. When the "pull" motion is then engaged the edge of the board is gripped and the frame automatically draws the load back on to the plate. The load can then be raised and transported for stacking.

For the stacking operation the load is positioned over the stack and lowered until the underside of the plate is just clear of the top of the stack. When the "push" motion is then selected by the operator the grip jaws open automatically and as the board with its load is pushed off the plate the truck is reversed away from the stack at the same speed.

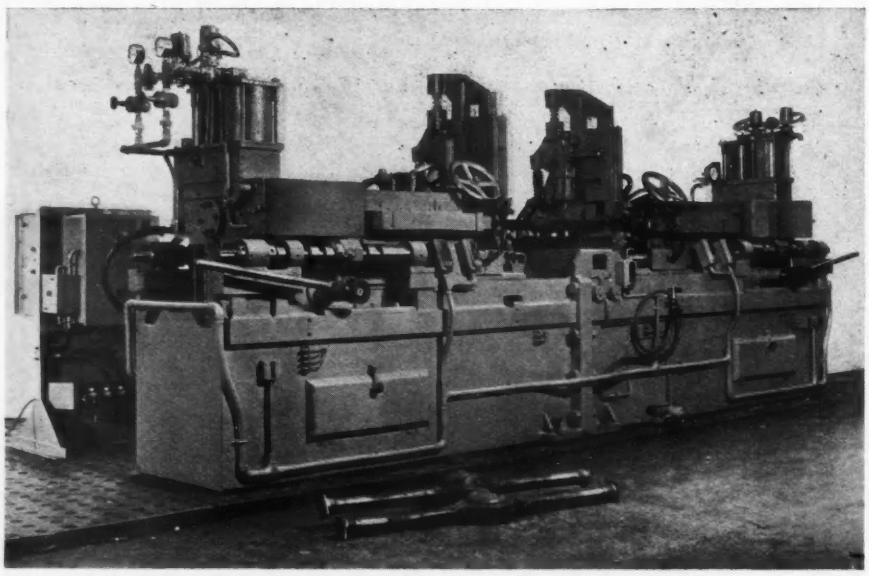


Fork truck attachment with frame extended ready to pull sheet of fibreboard with load on to load carrying platform

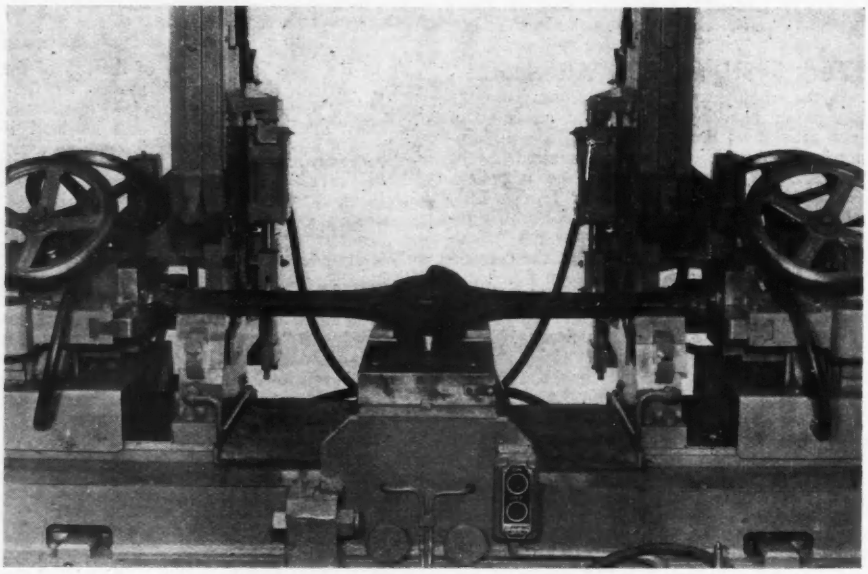
Mechanical Lime Spreader

We attended recently a demonstration of the Gibbon-Roadless lime spreader, a photograph of which is reproduced above. This machine, which is based on a Fordson "Major" tractor equipped with "Roadless D.G." half-tracks, is a product of Roadless Traction, Ltd., Gunnersbury House, Hounslow, Middlesex. As may be seen from the illustration, there has been some modification of the tractor to accommodate the spreader. The driver's seat, steering column and other controls have been moved from the central position to the left-hand side. This rearrangement has facilitated the mounting of the steel hopper, which has a capacity of 2 tons. The members carrying the hopper and distributor gear run right through from the front cross member of the tractor to the machined pads on the half-shaft housing, with an intermediate pick-up at the point where, on the sides of the tractor, there is a machined pad. The transference of the driver's seat and controls to the side, it may be mentioned, does not hinder the conventional use of the tractor with mounted implements.

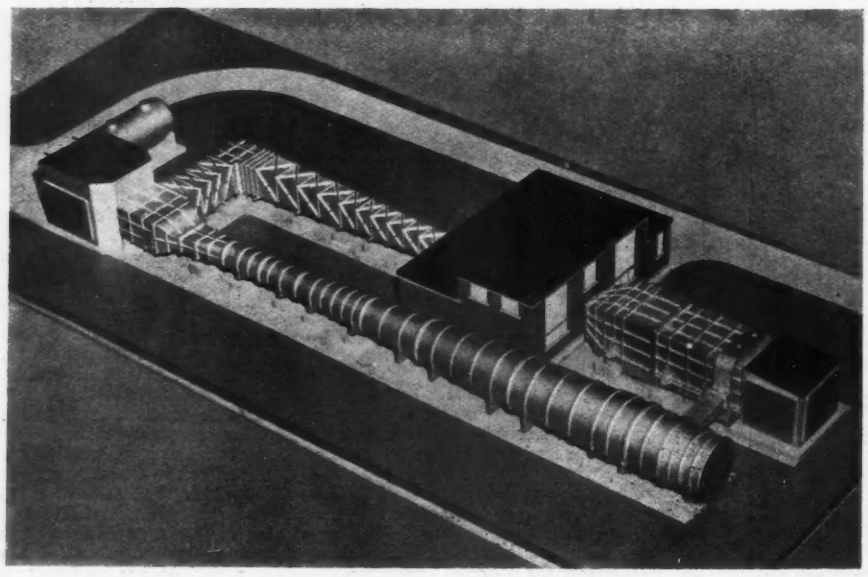
In this conversion the front wheels of the tractor are fitted with 9·00 × 16 pneumatic tyres. The standard half-track equipment provides for thirty-two track plates per track, 12in wide, with eleven grousers 4in deep by 8½in wide. The idler wheel rolling diameter is 25½in and the distance between the driving sprocket and idler wheel centres is adjustable from 22¾in to 24¾in. The approximate length of track in ground contact is 24in. The lime spreader assembly is made by Atkinsons Agricultural Appliances, Ltd., Clitheroe, Lancs. The steel hopper is provided with an endless rubber belt which carries the lime to the back of the machine, where it falls into a trough and is distributed by twin spinners rotating in opposite directions. The drive to the distributor mechanism is taken through vee-belts from the power take-off shaft of the tractor. Lime can be spread, it is claimed, at a rate varying from 1 cwt to 4 tons an acre to a width from 20ft to 25ft. The demonstration which we witnessed was given on distinctly "sticky" land with some steep gradients. The half-track equipment undoubtedly enabled the machine to show a satisfactory performance under particularly arduous conditions.



Double-ended automatic flash butt welder for motor-car rear-axle castings



Central jig with spigot location and welding dies



Model of open "U" steel circuit of 1·2 Mach number wind tunnel

Double-Ended Automatic Axle Casing Welders

THE accompanying illustrations show an automatic flash butt welding machine designed specially for the simultaneous automatic welding of the two end flanges on motor-car axle casings. It substantially reduces handling times on the complete assembly. This equipment was developed by A.I. Electric Welding Machines, Ltd., of Inverness, and 68, Victoria Street, London, S.W.1, and is installed in a works in the Midlands.

It is designed to accept the main axle casing with the two end flanges in one set up operation; the main axle casing is loaded on to the central jig with spigot location as shown in the second illustration, and is clamped by the air-operated clamping units at the extreme ends of the casing. As the central spigot is designed to take the reaction of upset or forging pressures, the holding-down clamp units exert only the pressure necessary for electrical contact, thereby reducing die wear to the minimum. The flanges are located on the electrode jig on each moving head, which are designed with quick-acting, short-stroke clamp action. In each flange clamp unit is incorporated a universal adjustment to bring the flange into alignment with the casing before the welding operation.

On both welding units the weld is initiated and completed under push-button control, and the assembly is completed in a time ranging from six seconds to twelve seconds, depending on the size of axle case being welded. At the end of the weld cycle the clamps are released and the completely assembled axle case is ejected from the dies by the air-operated lifting ejector system, and the casing is ready for transfer to the next operation in the production line. The moving heads of the welding units are reset and the machine is ready for reloading.

Both welding units are adjustable to take axle casings with overall dimensions from 30in to 62in. Provision has also been made in the machine to accept axle casings with offset differentials down to a minimum of 11in.

The equipment incorporates the manufacturer's air/oil intensifier power upset system, whereby an upset pressure of 8 tons is applied to the forging of the weld, and a simple adjustment enables the output of the power pack system to be adapted to suit any particular size of axle casing and tube dimension.

This system requires no oil pumps or accumulators: all that is needed is a connection to an 80 lb per square inch air supply main, the upset or forging pressure being developed by intensification within a one-piece power unit without high pressure joints.

Transonic Induction Wind Tunnel

A HIGH-SPEED, open-circuit induction wind tunnel is now under erection at the Queen's Island works of Short Brothers and Harland, Ltd. It will be driven by three Rolls-Royce "Nene 101" turbo-jet engines acting as inductors. It is designed to have a maximum Mach number of 1·2 and a working section of 2½ square feet.

In addition to the usual strain gauge balancing equipment it will be fitted with Schlieren optical equipment, and will run at atmospheric stagnation pressure and stagnation temperature up to 100 deg. Cent. to avoid condensation.

The structure is being built of steel by Harland and Wolff, Ltd., and the tunnel is expected to be ready by the middle of this year. As can be seen from the model illustration the "U" circuit follows the general pattern of other post-war transonic induction wind tunnels erected by aircraft manufacturers in this country. The transverse upstream ducting bleeds the tunnel exhaust to heat the intake air.

MACHYNLLETH "B" DIESEL ENGINE POWER STATION.—The Minister of Fuel and Power has given consent to the establishment of a new diesel engine power station in Montgomeryshire, to be known as the Machynlleth "B" power station. It will house three 1200kW sets and one 268kW set.

Rotary Straightening of Small Tubing

BY OUR AMERICAN EDITOR

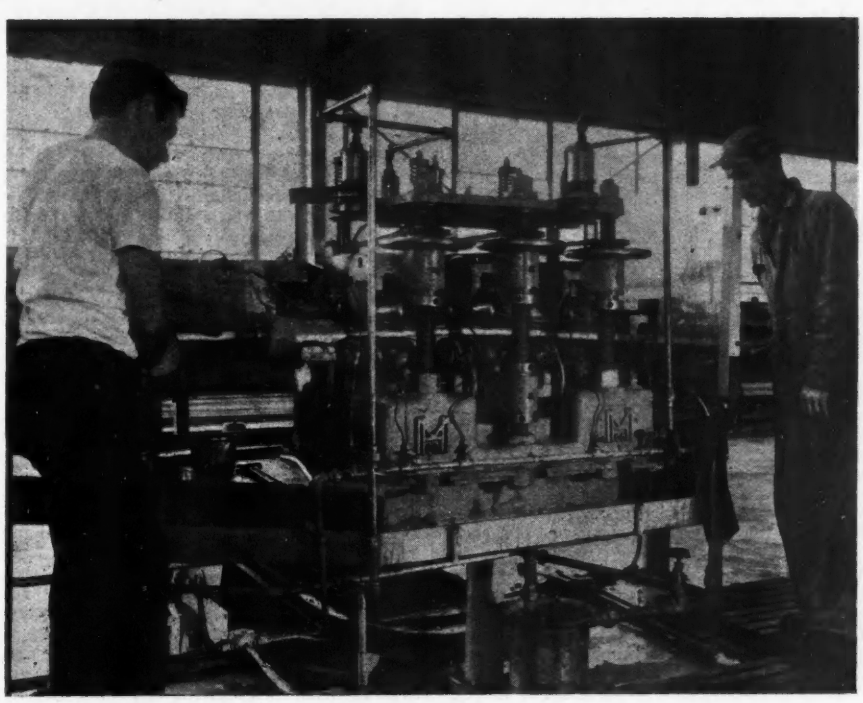
IT is well known to-day that in the manufacture of both seamless and welded tubes of relatively small diameter individual lengths of tubing easily become distorted. Because of unbalanced stresses within the metal which are created by uneven cooling or by hot or cold work, one length of tube may constrict into a "bow," while another may show a "hook" at one end. Other tubing becomes "wavy" with scarcely a single foot remaining in one and the same plane. This difficulty has come to be a major concern with the recent growth of commercial applications for tubing, resulting in a rising demand for close-tolerance tube straightness, as well as for precise diameters, roundness, controlled wall thicknesses, and good surface finish. To-day firms manufacturing various products from such tubing are demanding their suppliers to furnish tubing manufactured within increasingly narrow limits to suit their particular needs. In the United States this demand has led to the adoption of two basic ways to straighten tubing: the "two-plane" corrective bending method, and the "rotary" method. Where specifications allow a certain amount of latitude regarding straightness and roundness, the two-plane machines are popular, since they are fast, easy to feed, and will, if desired, straighten tubing directly from rough coils. They are limited, however, in their ability to achieve a complete straightening of bent tubing. Where almost perfect straightness is demanded, rotary straighteners are now being used. The fundamental difference between the two straightening methods lies in the fact that, while the first machine imparts corrective bending to the tube only on its horizontal and vertical axes, the rotary straightener feeds the tube continuously through a corrective bend or a series of bends which are effective in every axis of the tubing, thus producing the equalised residual stresses necessary to obtain true straightness.

The Mackintosh-Hemphill Company, of Pittsburgh, Pennsylvania, is at present one of the leading builders of such rotary straightening equipment in the United States. Shortly after the end of the last war, this company undertook the development of rotary straighteners for ferrous and non-ferrous tubing, in various size ranges down to a minimum of $\frac{1}{8}$in O.D. Such machines are now available for handling pipe or tube with an O.D. range of from 5in to 15in, down to handling tubing or rods with an O.D. range of from 0·050in to 0·250in. All of the rotary straighteners made by the company for straightening small size tubing employ six rolls arranged so that the tube rotates through three successive closed cross-roll passes. Two rolls, one vertically above the other, form each of the three closed passes. All six rolls are driven and are identical in body length and contour to ensure equalised driving contact with the tube. The accompanying illustrations show two representative machines being used to straighten titanium alloy tubing in sizes up to 1¼in O.D. at the Superior Tube Company, Norristown, Pennsylvania.

Straightening is accomplished by vertically off-setting the centre cross-roll pass relatively to the fixed-level entry and delivery passes. During rotation through the off-set cross-roll pass, all parts of the tube in every plane are subjected to complex multiple bend cycles. This strains the metal of the tube sufficiently beyond its elastic limit to overcome any existing unbalanced stresses. The tube emerges from the machine perfectly straight because the residual stresses throughout its cross section have become balanced and equal. All three upper rolls are adjustable vertically to suit the size of the tube. The lower middle-pass roll is adjustable vertically to permit the middle-pass off-set. The lower entry and lower delivery rolls are fixed in the vertical direction. All six rolls can be rotated from their normal cross-roll operating angle of 30 deg. so that practically continuous contact can be obtained between the generated concave curve of the roll body and the various tube diameters within the capacity range of the straightener. Therefore, only one set of six rolls is required to handle the full range of tube sizes of each individual machine.

The Mackintosh-Hemphill rotary straightener now offers production speeds approximating to that obtainable from the conventional two-plane straightener. The normal maximum operating speeds of the machines vary from 70ft to 800ft per minute. The design of the machines requires no tube guides, and thus eliminates the major source of spiral scratches and marks on the tube surface. Entry and delivery tube handling tables for the machines have been carefully designed to suit the straightening of various types of tubes. These tables must readily accept bent tubing, neatly and safely restrain the action of the unstraightened length of tube as it rotates through the straightener, and at the same time offer the least amount of frictional drag to the revolving tube. The entry tables generally take the form of a long and narrow open-top box with an inner lining, to avoid abrasive marring of the tube surface. Occasionally a line pipe is used through which tube can be continuously fed into the straightener. Boxes are normally used where sufficient working space is not available to allow for the extra feeding length required by a pipe feed. The entry boxes, or, as they are sometimes called, "whipping troughs," are often equipped with a hinged lid. The lid protects the operator against any possibility of the tube coming out during the

Straightening of titanium tubing at the Norristown works of the Superior Tube Company



Straightening of aluminium tubing at the Los Angeles works of Revere Copper and Brass, Incorporated

straightening process. An optional entry trough is often used which has a longitudinal slot through which bent tube can be inserted, but is shaped so that rotating tube cannot emerge from it.

On the delivery side of the tube straightener, a simple run-out surface is satisfactory if it has a vertical board on the drive-side edge of the run-out table, against which the straightened tube can spin. If the tube surface finish must be guarded, the delivery table should be lined with soft wood, brass, or a plastics material on both the vertical and the horizontal surfaces. Such a lining avoids the possibility of spiral scratches on the surface of the tube. The emerging tube requires support immediately it leaves the straightener. For this reason the end of the delivery table next to the machine should be movable to allow the table to be in proper alignment with the straightener. Rotary straighteners equipped with entry boxes and delivery tables are to-day straightening a wide variety of ferrous and non-ferrous tubing, including copper, brass, aluminium, stainless steel, titanium, carbon, alloy and stainless steels, monel, phosphor bronze, nickel silver and cupro-nickel.

Flood Lubrication Systems

Some models of these straighteners are equipped with a circulating flood lubrication system. Experience obtained in works processing aluminium and other non-ferrous metal tubing, indicated that the application of a petroleum-base liquid solvent was advisable. Such a liquid is directed at the points where the tubing contacts each pair of rolls, and materially improves the straightening operation, washing away metal particles which might have marred the metal tubing surface and dissolving the residue of the solutions used in previous drawing operations. One of the illustrations on page 431 shows a rotary straightener equipped with such a flood lubrication system. It is in operation at the Los Angeles works of Revere Copper and Brass, Incorporated, and is used to straighten aluminium tubing in 60ft maximum lengths, ranging from ¼in to 1¼in O.D., maintaining a straightness tolerance of 0·010in per foot.

75th Anniversary of the American Society of Mechanical Engineers

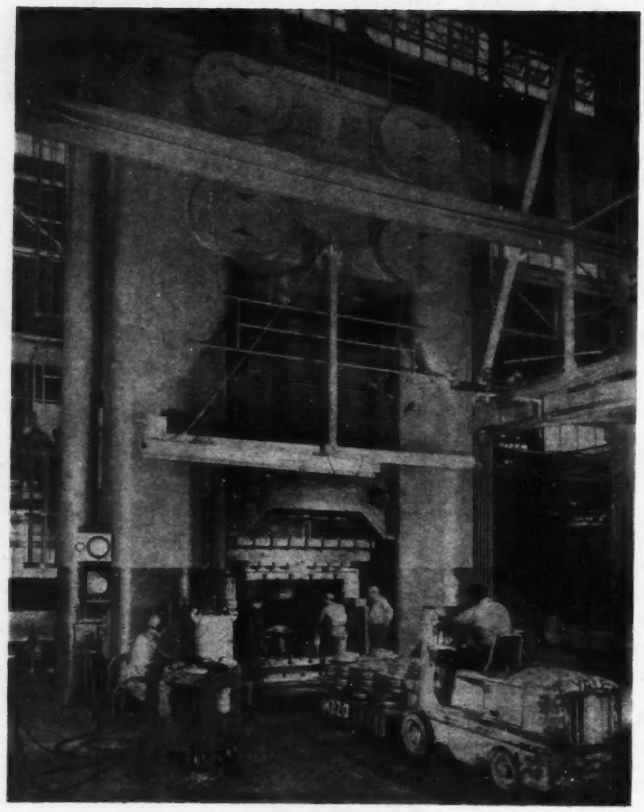
A celebration took place in New York on February 16th, to commemorate the initial meeting which was called in the offices of the *American Machinist* by Professor John E. Sweet on February 16, 1880, to discuss the formation of a national institution of mechanical engineers.

The morning session was held in the offices of the McGraw-Hill Publishing Company, the publishers of the *American Machinist*, and was the occasion for greetings to be presented to the A.S.M.E. by various organisations representing the American trade and technical press. Following a buffet luncheon, the meeting adjourned to the Engineering Societies Building, where an afternoon panel session on "The Engineer and his Communications" included the following participants: Edgar Kobak, a business consultant and former vice-president of the McGraw-Hill Publishing Company, speaking on the engineer's communications with those outside his profession; James G. Lyne, president of the Simmons-Boardman Publishing Company, speaking on the engineer's communications with other engineers; Ormand J. Drake, assistant secretary of New York University, speaking on the engineer's personal communications through writing and speaking; and E. W. Engstrom, executive vice-president of the Radio Corporation of America, speaking on what the engineer has meant to communications.

In the evening, a banquet was held at the Waldorf-Astoria Hotel, which was presided over by William L. Batt, a past-president of the Society. The main speaker of the evening was Dr. Vannevar Bush, president of the Carnegie Institution of Washington, and an Honorary Member of the A.S.M.E., who chose as his subject "Communications—Where Do We Go From Here?"

8000-Ton Hydraulic Forging Press

An 8000-ton hydraulic forging press recently went into operation at the Cleveland works of the Aluminum Company of America. The machine was supplied to the company under a lease arrangement with the U.S. Air Force, and fills an important gap in the existing range of aluminium, magnesium and titanium forging equipment at the Cleveland works, which includes presses with capacities of 1500 tons, 3000 tons and 15,000 tons, respectively. The considerable size of the press is indicated by its overall height of 55ft, of which 38ft is above floor level. The die area, in which forgings can be produced, is 11ft 6in long and 4ft 6in wide. Large precision aircraft forgings of close tolerance and low draught will be an important product of the press. The large die area will allow the production of big forgings which do not require the tremendous pressures of the 15,000-ton press now in production or the 35,000-ton or 50,000-ton presses which will be in operation in Cleveland later this year.



8000-ton hydraulic forging press at the Cleveland works of the Aluminum Company of America

Among the unusual aspects of the 8000-ton press are its departure from the conventional tie-rod design to increase the rigidity and accuracy of its large die area. Most large hydraulic presses are held together by a number of threaded tie-rods which act to restrain the press from elongation as pressure is applied to its dies. The present machine, which was designed and built by the United Engineering and Foundry Company, of Pittsburgh, Pennsylvania, is composed of a number of extremely large castings joined together to act as one. As shown in the accompanying illustration, these castings are held together by shrink links. On erection of the press, these rings were heated and fitted over lugs on each of the big castings. As they cooled and contracted over the lugs, they began to hold the castings firmly together. The rigidity produced by this method of construction is said to permit extremely accurate guiding of the forging dies and to allow closer tolerance work. The press weighs 3,900,000 lb, or about twice as much as a conventional single-cylinder 8000-ton press. The machine has a working stroke of 6ft and a 3in-per-second pressing speed. The controls on the press are portable and can be positioned to allow the operator the best vantage point for controlling operations. Hydraulic pressure to operate the press is supplied by three 700 h.p. pumps and is stored in a 600-gallon accumulator at 4500 lb per square inch.

Manufacture of Artificial Diamonds

The General Electric Company, of Schenectady, New York, has announced that its research laboratory has succeeded in the manufacture of artificial diamonds. The largest stone made so far by the company is only $\frac{1}{16}$in long, and the research and development costs that went into it probably make the fragment "the most costly diamond ever displayed." The true status of previous attempts to make diamonds is difficult to determine with certainty. A Frenchman, C. Cayniard de la Tour, claimed success in 1828. Three years ago, the Prism-Lite Diamond Company claimed to have made a synthetic diamond usable for cutting, grinding and other industrial purposes. However, research by General Electric appears to have resulted in a method in which diamonds can be made in a predictable and routine way. For the present, it was stated by Dr. C. Guy Suits, director of research of the company, "any conclusion that we are about to make diamonds of a size and quality suitable for gem use is decidedly premature." What the future holds cannot be foreseen. Industrial diamonds made by the present process are too costly to compete with industrial stones at 7000 dollars a pound, it was said. In The General Electric process, pressures and high temperatures never before achieved in the same container were used to make diamonds: pressures of 1,500,000 lb per square inch and temperatures of 5000 deg. Fah. were maintained within the dies of a 1000-ton press. Under the heat and pressure, carbon atoms changed their alignment to take up the crystalline structure which makes a diamond. Varieties of colour, clarity and crystallinity found in natural diamonds have been observed in the man-made diamonds.

A.E.C. Distinguished Service Award to Dr. Hafstad.—Dr. Lawrence R. Hafstad, who retired recently as Director of the U.S. Atomic Energy Commission's Division of Reactor Development, has been granted the Distinguished Service Award of the A.E.C. The award, which was established in January, 1954, is granted in recognition of exceptionally meritorious and effective performance of duty by staff members. Dr. Hafstad was responsible for the development of the Commission's reactor programme and the completion of the first generation of post-war reactors. Under his guidance, the country's first electric power was produced from nuclear fuel at the National Reactor Testing Station. He pioneered and administered with the Department of Defence a programme for the development of military nuclear power plants for the Navy, Air Force and the Army, including the first nuclear powered submarine, the "Nautilus." He was instrumental in the formulation of a programme of participation by industry, both technically and financially, in the development of nuclear power plants. Under his leadership, the nation's first civilian nuclear power plant was recently placed under construction near Pittsburgh, Pennsylvania. Significant achievements in the development and improvement of nuclear reactors since 1949 attest to the importance of his contribution to the advancement of the national atomic energy programme.

Industrial and Labour Notes

Overseas Trade

The Board of Trade accounts for February give the value of United Kingdom exports as £232,800,000, in the twenty-four working days of the month. Taking the two months of January and February, the average value of exports was £240,700,000, which was 13 per cent above the figure for the corresponding months of last year. The Board of Trade says, however, that in making this comparison it should be noted that the figures for February this year, as for January, were probably higher than they would have been, but for the dock strike last autumn. The delay then caused in shipping goods led to some dislocation of production schedules and of shipping time-tables, and it is impossible to say for how long these factors will continue to influence the monthly export totals. The Board of Trade suggests that the most reliable comparison which can be made is between averages for the months October to February, covering the period of the strike and its after-effects, and the corresponding months a year earlier. On this basis, the monthly average for 1954–55 was £230,000,000, compared with £224,000,000 in the 1953–54 period.

This moderate expansion in exports, the Board of Trade points out, has been accompanied by a large increase in the value of imports. Last month the value of imports amounted to £309,500,000 and the January–February average was £320,500,000, which was 22 per cent above the figure for a year earlier. Furthermore, this increase probably included only a small element of "strike effect." The Board of Trade says that there were three main factors, the first of which was the higher rate of consumption and usage of many foods and industrial materials. Then, there was a marked increase in average values (c.i.f.) following the widespread rises in commodity market prices and freight rates in earlier months. There is also some evidence that stocks held by manufacturers and merchants have increased in the last few months, partly to make good deficiencies in working stocks caused or disclosed by the dock strike and partly to insure against further price increases. The Board of Trade says that it is difficult to apportion the increase in total imports among these factors, but it should be noted that market prices of many commodities fell in February, though not by as much as their earlier increase. Re-exports in January and February averaged £9,600,000 a month, and the excess of imports over total exports was £70,100,000 a month.

The Board of Trade adds that, with average import prices substantially higher than a year ago, the volume of imports has increased much less than the value. Export prices, on average, have changed little, but exports of some goods which have decreased in price have expanded more than the average and the volume comparison with a year ago is rather more favourable than that by value. It has been estimated that the volume of both imports and exports in January and February was about one-seventh higher than in the corresponding months last year. In the period October, 1954, to February this year, both imports and exports increased in volume by 5 or 6 per cent compared with a year earlier.

Miners' Wages

A delegate conference of the National Union of Mineworkers, which was held last Friday, signified its approval of the new wage rates for day workers agreed upon earlier in the week by the executive of the union and the National Coal Board. The agreement represents part of the revision of the mining industry's wages structure. This revision has been going on for some time with the object of grading the various jobs performed by both underground and surface workers. The first stage of the revision involved the preparation of "job descriptions" defining the 350 or so different tasks done by mineworkers in and about the pits and in the central workshops serving the industry.

The second stage was to grade these in accordance with their relative importance. Underground jobs were classified in five grades, surface jobs in five grades, and the jobs done by craftsmen were put into three grades. The jobs being performed by men in the various collieries were then jointly assimilated into these thirteen grades. The agreement reached between the Coal Board and the union executive related to the wage rates which should be paid for these grades. The new rates mean that the minimum weekly wage of the lowest grade of underground mineworkers will be increased by 11s. 6d. to £8 6s. 6d., and for surface workers in the lowest grade there will also be an increase of 11s. 6d., bringing the weekly minimum wage to £7 6s. 6d. Men engaged on first-grade jobs underground will have their basic weekly wage increased to £9 10s. 6d., and surface workers in the first grade will receive a basic wage of £8 4s. 6d. a week. It has been estimated that the increases will cost approximately £13,000,000 in a full year.

Coal Production and Supplies

Several questions concerning coal output and coal stocks were addressed in Parliament last Monday to the Minister of Fuel and Power. In his replies, the Minister said that London house coal stocks were well above the average for the time of year and that industrial stocks were generally sufficient. Special action had been taken to help gasworks in two or three towns and power station stocks were at a safe level.

The Minister went on to say that output of coal in this country increased last year until the winter, when it started to decline. In the first ten weeks of this year it was 1,100,000 less than in the corresponding period of 1954 and 3,500,000 tons less than current inland consumption. It was, therefore, fortunate that arrangements were made last summer for large imports to come in throughout the winter months. About coal production, the Minister said that 40 per cent of the decrease this year had been in respect of opencast and not deep-mined coal and almost half the reduction in output from the deep mines had been due to a difference in the onset of holidays, particularly in Scotland. Nevertheless, he added, it was true that output had been disappointing and he was glad that the last two weeks had shown a pronounced upward improvement.

The latest figures published by the Ministry of Fuel and Power show that last week's saleable output of coal was 4,601,100 tons, which included 4,390,000 tons from the deep mines and 211,100 tons from opencast sites. In the comparable week last year, the total output amounted to 4,609,300 tons. In the first eleven weeks of this year ended last Saturday, output totalled 49,501,700 tons, compared with 50,572,900 tons in the corresponding period of 1954. Imports of coal in the first ten weeks of this year were 1,988,500 tons.

Scientific and Technical Personnel

In his chairman's address at the annual meeting of The English Electric Company, Ltd., on Thursday of last week, Sir George Nelson made reference to the shortage of scientific and technical personnel. He said that their numbers could not be increased overnight; on the contrary, it needed a period of training from schools, technical colleges and universities over several years. It was necessary, therefore, for Government scientific establishments and industry to ensure that the available technical personnel were used in the most efficient way and that duplication of development should be avoided wherever possible.

Sir George went on to express his confidence that with such adequate and appropriate action, both by the Government and industry, the country's general economic position could be still further improved. Technical personnel and higher executives, he continued, were the foundation from which our national economy sprang. Unfortunately, industrialists were unable to give them appropriate encouragement for the work they did because taxation took away so much of what was paid them. If the Chancellor of the Exchequer found himself able to give relief in the standard rates of income tax, and so ease the heavy burden on leading executives, he would be providing a further encouragement to them and thus a great stimulus to the country's trade.

Railway Freight Charges

The British Transport Commission has published its proposals for new maximum charges in respect of merchandise carried on the railways. The scheme covers charges and conditions of carriage for all merchandise and livestock taken by goods or passenger trains, with the exception of passengers' luggage. The charges to be made are left to the discretion of the Transport Commission, which discretion, it is explained, will be exercised commercially.

The charges are set out in a series of scales governed by the weight of the consignment and what is described as its "loadability." "Loadability" is defined as a method of measuring the relative quantity of any given traffic capable of being loaded into a wagon. The scheme thus provides for a policy of rate making which will encourage the tendering of traffic in wagon-load consignments. The new rates are expressed in the form of a charge per ton for the first 10 miles, including terminal accommodation and service, and an additional charge per ton for each succeeding mile. The charges are on a station-to-station basis.

The scheme is to go to the Transport Tribunal for approval, and if approved it is stated that most of the existing rates will continue in force for the time being to enable a review of them to be undertaken. The British Transport Commission says that, in making such a review, it will adjust charges either upward or downward as part of a process of evolving a flexible system based on business principles.

British Railways Productivity Council

Last week in Parliament, Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour, stated that proposals had been made for the setting up of a British Railways Productivity Council. He said that the British Transport Commission had suggested the establishment of such a body to the three railway unions and to the Confederation of Shipbuilding and Engineering Unions, and that the unions had agreed in principle.

On Thursday of last week, representatives of the British Transport Commission and of the unions held a meeting to discuss the proposed council's terms of reference. Afterwards, it was stated that these terms, and the membership of the council, would be announced when approval had been given by the executive of the National Union of Railwaymen. It is understood that the council will consist of eighteen members, nine representing the British Transport Commission and the regional managements, and nine representing the unions.

Industrial Health Services

In these notes in our issue of November 19th last, reference was made to the proposal to set up an Industrial Health Advisory Committee. That committee has now been constituted, with the Minister of Labour as chairman, its function being to advise the Minister on measures designed to further the development of industrial health in work places covered by the Factories Acts. The first meeting of the committee was held on Friday last under the chairmanship of the Parliamentary Secretary to the Ministry of Labour, Mr. Harold Watkinson. Mr. Watkinson emphasised the broad scope of industrial health services in factories, which, he said, covered the provision of a good working environment to promote health, cleanliness, good sanitation, lighting, heating, ventilation and atmosphere. The committee decided that at its next meeting, to be held on May 19th, it would consider the problem of priorities in the field of industrial health.

Personal and Business

Appointments

MR. L. KEARTON PARKER has been appointed chief sales engineer of Winston Electronics, Ltd., Hampton Hill, Middlesex.

MR. W. U. SNELL, M.I.Mech.E., has been appointed executive assistant to Air Commodore F. R. Banks, director of The Bristol Aeroplane Company, Ltd.

MR. J. A. R. PIMLOTT, an under-secretary of the Board of Trade, has been appointed secretary of the Monopolies and Restrictive Practices Commission.

LONDON TRANSPORT announces the appointment of Mr. F. S. P. Turner, A.M.I.C.E., as principal executive assistant in the office of the new works engineer.

MR. A. O. BLUTH has joined the board of Vickers, Ltd. He is a director of Vickers Armstrongs, Ltd., and vice-chairman and joint managing director of the Jack Olding organisation.

MR. A. G. F. FARQUHAR has been appointed deputy secretary of the British Electricity Authority. He was formerly assistant secretary in the electricity division of the Ministry of Fuel and Power.

MR. H. E. TURNER has been appointed service and home sales manager of The Parsons Engineering Company, Ltd., Southampton. He joined the company shortly after its formation in 1904.

MR. J. R. HARDING, M.I.E.E., has been appointed general manager of Pirelli-General Cable Works, Ltd., Southampton. He succeeds Mr. W. W. Wood, M.I.E.E., who has retired from that position, but who will continue as a director of the company.

BRITISH RAILWAYS state that Mr. J. R. Dallmeyer, M.I.C.E., has been confirmed in the position of assistant civil engineer, Eastern Region, King's Cross, in which he has been acting since February, 1953.

MR. J. PALMER REES, A.M.I.E.E., White Lodge, Ogmore-by-Sea, Glamorgan, has been appointed local representative in South Wales for the land products of Richardsons, Westgarth (Hartlepool), Ltd.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces the appointment of Mr. J. D. Mosley, A.M.I.E.E., as district erection engineer for London. He joined the company as a college apprentice in 1935.

MR. DAVID BRUCE and Mr. H. O. Hinton have been appointed to the board of H. Widdop and Co., Ltd., Keighley. Mr. Bruce is the managing director of British Polar Engines, Ltd., and Mr. Hinton is commercial director of Associated British Engineering, Ltd.

MR. G. M. WELLS and Mr. I. G. Hopkinson have been appointed directors of Hopkinsons, Ltd., Huddersfield. Mr. Wells joined the company in 1934 and has been London manager since 1939. Mr. Hopkinson, who joined the company in 1938, has been works manager since 1947.

THE MINISTRY OF SUPPLY announces the appointment of Mr. J. Hanson as chief superintendent, Aeroplane and Armament Experimental Establishment, Boscombe Down. Mr. C. Dunbar has been appointed deputy chief engineer, tracked vehicles, at the Fighting Vehicles Research and Development Establishment, Chertsey.

MR. D. J. C. ROBERTSON, A.M.I.Mech.E., has been appointed production general manager and a director of Metropolitan-Cammell Carriage and Wagon Company, Ltd., Saltley, Birmingham, 8, in succession to the late Mr. Norman Haddon. Mr. Robertson has also been appointed to the board of Metropolitan-Cammell-Weymann, Ltd.

J. and H. McLaren, Ltd., Leeds, announces the following appointments: Mr. D. F. Pickering, A.M.I.Mech.E., assistant sales manager; Mr. Eric Robinson, sales representative in N.W. England; Mr. James Mackie, sales representative in South Scotland; Mr. T. J. Gerry, assistant sales representative in London and the home counties.

Business Announcements

Q.V.F., Ltd., has opened new London offices at 81, Cromwell Road, S.W.7 (telephone, Freemantle 4811).

THE ASSOCIATION OF PUBLIC LIGHTING ENGINEERS has moved to 17, Victoria Street, Westminster, S.W.1 (telephone, Abbey 4281).

ABELSON AND CO. (ENGINEERS), Ltd., states that its London office has been moved to 60–62, Clapham Road, S.W.9 (telephone, Reliance 5326).

CARTER GEARS, Ltd., Thornbury Road, Bradford, states that it is now represented in Australia by T. K. Steanes and Son Pty., Ltd., 418, Military Road, Mosman, N.S.W.

CABLE AND WIRELESS, Ltd., is to open a new training school at Electra House, Hong Kong, on April 1st. Mr. A. F. Sutcliffe is to be instructor-in-charge of the new school.

THE BUTTERLEY COMPANY, Ltd., has moved its London offices to 9, Upper Belgrave Street, S.W.1 (telephone, Sloane 8172 and 9106; telegrams, "Butterley Sowest London").

DR. HENRY SELIGMAN, head of the isotope division of Harwell research station, is to visit Greece and Turkey to lecture for the British Council on the medical and industrial application of radio isotopes.

DUNLOP SPECIAL PRODUCTS, Ltd., has moved its headquarters to Allington House, 136–142, Victoria Street, London, S.W.1 (telephone, Victoria 6868; telegraphic address, "Dunsport, Wesphone, London").

CAMBRIDGE INSTRUMENT COMPANY, Ltd., announces that it has established a mechanical thermometer division at its additional factory at Friern Park, North Finchley, London, N.12 (telephone, Hillside 5016; telegrams, "Fincamo London N.12").

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., has established a section at its Loughborough works to study the special requirements of electricity generating stations powered by nuclear energy. This section is under the direction of Mr. J. H. R. Nixon, M.I.Mech.E., M.I.E.E.

THE SPENCER WIRE COMPANY, Ltd., Wakefield, has acquired the business and plant of The Midland Expanded Metal Company, Ltd., Tipton, Staffs. The latter company's business has now been transferred to Wakefield. The head sales office is at 53, Victoria Street, London, S.W.1 (telephone, Abbey 6373), under the direction of Mr. John B. Liddell.

THE ENGLISH ELECTRIC COMPANY, Ltd., states that its offers to acquire all the ordinary stock of The Vulcan Foundry, Ltd., and all the stock of Robert Stephenson and Hawthorns, Ltd., not held by The Vulcan Foundry, Ltd., have in each case been accepted by the holders of more than 90 per cent in value of the stocks concerned and have accordingly become unconditional.

VACUUM OIL COMPANY, Ltd., announces the retirement of Mr. O. T. Jones, M.I.Mech.E., from the position of chief automotive engineer, after thirty-five years' service. His successor is Mr. C. G. Tresidder, A.M.I.Mech.E., who joined the company's staff in 1946. Another retirement announced by Vacuum Oil Company, Ltd., is that of Mr. E. R. Blane, associate technologist at the Wandsworth central laboratories. Mr. Blane, who has completed over twenty years' service, is remaining with the company for a time as a full-time consultant.

Miscellanea

MR. E. R. ELLISTON.—We have learned with regret of the death of Mr. Ernest Robert Elliston, which occurred on March 13th. Mr. Elliston was the chairman, managing director and co-founder of Elliston, Evans and Jackson, Ltd., Bridgwater, Somerset.

SHORT HISTORY OF BORAX.—Borax Consolidated, Ltd., has published a booklet entitled "The Borax Story," which briefly traces the history of the discovery and development of Borax, and then discusses its present uses in a number of industries, including agriculture, glass making, &c. Possible new applications in the future are examined and the possibilities of the new "organic borates" as oil and petrol additives and for other purposes.

DEBATE ON THE ROAD PROGRAMME.—The Institution of Highway Engineers has organised a debate on the Government's road programme. The principal speakers will be Mr. C. T. Brunner (vice-chairman, British Road Federation), Lieut.-Col. A. C. Newman (W. and C. French, Ltd.), and Sir Owen E. Williams (consulting engineer). The debate is to be held at the Institution of Structural Engineers, 11, Upper Belgrave Street, S.W.1, on Friday, April 1st, at 5.30 p.m.

RAND WATER BOARD.—We have received a copy of the annual report for the year ended March 31st of the Rand Water Board. This South African water undertaking supplies an average of nearly 110 m.g.d. to Veeriniging, Johannesburg, Pretoria and the surrounding areas. The principal source of supply is the Vaal River. It is expected that the demand will show appreciable increases over the next few years, and a further duplication of the Daleside–Zwartskopjes 54in diameter main is envisaged to cater for the estimated consumption by 1957.

PREMIUMS FOR TECHNICAL WRITING ABOUT RADIO.—Six premiums of 25 guineas each awarded by the Radio Industry Council for articles published in the technical press, were presented at a luncheon at the Café Royal on Thursday, March 10th. Two of these premiums were awarded to the authors of a group of three articles that appeared in *Electronic Engineering* — "Leo - Lyons' Electronic Office," by J. M. M. Pinkerton and E. J. Kaye, July, 1954; "Leo-Operation and Maintenance," by E. H. Lenaerts, August, 1954; and "Leo—a Checking Device for Punched Data Tapes," by E. J. Kaye and G. R. Gibbs, September, 1954. One premium was awarded to H. S. Jewitt, the author of two articles published in *Wireless World*—"Wide Band I.F. Amplifiers," February, 1954, and "Feedback I.F. Amplifier for Television," December, 1954. One premium was awarded to A. E. Maine, the author of two articles published in *Electronic Engineering*—"High-Speed Magnetic Amplifiers," May, 1954, and "Three Phase High-Speed Magnetic Amplifiers," December, 1954. One premium was awarded to J. F. Field and D. H. Downs for their article, "A Torquemeter for Testing Gas Turbine Components," in *Electronic Engineering*, November-December, 1954. One premium was awarded to W. R. Cass and R. M. Hadfield for their article "Dip Soldered Chassis Production," in *Wireless World*, November, 1954.

SPIRAL FLUTED COUNTERBORES.—Particulars have been received from Clarkson (Engineers), Ltd., Nuneaton, of a new range of spiral fluted counterboring tools with threaded shanks which the firm is now making for use with its "Autolock" chucks. These tools are made in twelve sizes suitable for counterboring holes for bolt heads from 4BA to 1in. The cutters have two quick spiral flutes which give a positive rake to the end teeth, ensure a clean cutting action, clear swarf well, and leave a good finish in the counterbore.

WORKING MODEL OF AN ATOMIC PILE.—The United Kingdom Atomic Energy Authority has lent to the Science Museum, South Kensington, London, S.W.7, a large working model showing the "B.E.P.O." atomic pile, the larger of the two pioneer piles at Harwell. This pile went into operation in July, 1948. The model goes through a complete cycle of operations in five minutes, and shows the working of the control and shut-down rods which govern the heat output of the pile, and the movement of the hoist for loading uranium rods into the pile. It is on view in a recently opened ground floor gallery of the Museum.

ULTRA HIGH-SPEED "CAMERA" OR SEQUENTIAL IMAGE CONVERTER.—British equipment, described as the world's fastest camera, was despatched from London Airport to New York by the first flight of a new trans-atlantic freight service inaugurated by Airwork, Ltd., on Tuesday, March 1st. The "camera" is known as a "sequential image converter." It consists of a power unit and an optical unit, each contained in a separate cabinet. These units control electronically a Mullard image converter tube on the screen of which six sequential pictures are produced. Exposures of one ten-millionth of a second can be taken at a frame rate of two million per second, which is stated to be at least twenty-five times as fast as by any other photographic method. The camera was designed and made by Winston Electronics, Ltd., Hampton Hill, Middlesex, for the United States Government, and it will be used in weapon testing at the Aberdeen proving grounds.

SURFACE COATING RESINS INDEX.—For the first time a comprehensive index of British surface coating resins has been compiled in a booklet, prepared jointly by the surface coating resin section of the British Plastics Federation and the Surface Coating Synthetic Resin Manufacturers' Association. It lists in fourteen tables the basic information on all the British-made surface coating resins at present available to the paint, printing ink and allied trades. So far as their complex chemical nature will permit, the resins—733 in all—have been classified and within each of the fourteen classifications they have been listed in alphabetical order by trade name. There is a list of all the producers contributing and, for easy reference, indexes both to producers and to trade names. The booklet is available from the British Plastics Federation, 47, Piccadilly, London, W.1, or the Surface Coating Synthetic Resin Manufacturers' Association, 79–80, High Holborn, London, W.C.1, price 3s. (post free).

SHUNTING LOCOMOTIVES.—The first of the fifteen standard 0–6–0, 350 h.p., diesel-electric shunting locomotives with B.T.H. power equipments has been placed in service at the British Railways shunting yards at Immingham. The mechanical parts for these locomotives are being made at the British Railways locomotive works at Darlington, and closely follow the standard mechanical design and outward appearance which has been adopted for this class of locomotive. The Lister-Blackstone "ERT6" diesel engine, rated 350 h.p. at 750 r.p.m., drives a directly coupled and spigot-mounted B.T.H. traction generator, the complete set being supported on the locomotive frame at three points. A belt-driven exciter and an auxiliary generator are mounted on top of the main generator, with a centrifugal blower for the traction motors overhung from the exciter. The two outer axles are driven through double-reduction spur gears by forced-ventilated traction motors, arranged for spigot mounting on their gearboxes.

"PLANNED FOR THE PURPOSE."—A sound film, entitled "Planned for the Purpose," has been produced by British Electrical Development Association (B.E.D.A.), 2, Savoy Hill, London, W.C.2. It deals broadly with the subject of industrial engineering and it shows the importance of plant siting and layout, materials handling and work flow in the planning of new products. The differences between mass, batch and unit production are drawn and the theme is illustrated by three narratives: the first describes the planning and operation of a factory for the quantity production of a new line of electric cookers; the inter-relationship between the design of a modern cooker and the production methods applied to its manufacture are brought out. The second narrative concerns a modern laundry and the third illustrates the production of a special batch of components by a firm of machine tool makers. The film, 16mm and 35mm, runs 53 minutes, and is available free, on loan, from the B.E.D.A. at the address given above.

British Patent Specifications

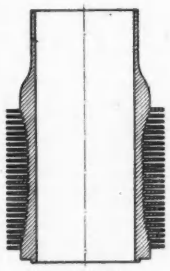
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2 2s. 6d. each.

METALLURGY

724,979. March 24, 1953.—GREY IRON FINNED CYLINDERS FOR INTERNAL COMBUSTION ENGINES AND COMPRESSORS, Heinz Teves and Ernst Teves, both of Rebstockerstrasse 41, Frankfurt/Main, Germany, partners of the firm Alfred Teves Maschinen-Und Armaturenfabrik Kommanditgesellschaft. (*Inventor: Franz Brugger.*)

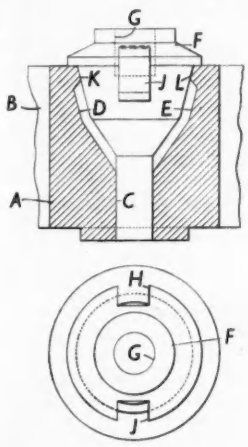
According to the invention the cylinder is produced by centrifugal casting, the fins being formed in a mould or core produced in a separate moulding machine. The mould for the fins is divided and is fitted in the centrifugal casting machine. The casting composition is so chosen that the cylinder bore has high wearing properties. Although such a material only flows with difficulty, the fins, when using centrifugal force for filling the mould, are formed satisfactorily by the centrifugal force. By adding influencing admixtures such as silicon aluminium, carbon or graphite powder or the like to the moulding mass of the mould for the fins, a super-cooling of the melt is prevented and thus the graphitic solidification of the fins is assisted. In this way, it is possible to arrange at least eighteen fins of a thickness of about 1·6mm with a spacing of about 3·5mm and a height of 25mm on a cylinder length of approximately 100mm. After the centrifuging, the still red-hot fins are subjected to a slow cooling process and a ferritic structure is obtained. The invention is not limited to the constructional example shown, and the cylinder can be given any other shape and number of fins.—*February* 23, 1955.



No. 724,979

724,158. August 20, 1952.—LADLE FOR TEEMING MOLTEN METAL, Joseph Jenkins, 174, Wallwood Road, Leytonstone, London, E.11, and formerly of 34, Clifton Square, Corby, Northamptonshire.

It is an object of the invention to provide a ladle with a stopper and nozzle with the aid of which the rate of teeming can be controlled continuously from zero up to a predetermined maximum. Referring



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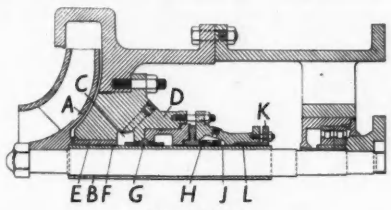
to the drawing *A* is a refractive brick built into the bottom of a ladle *B*. The brick has a bore *C* forming a nozzle, the lower portion of which is cylindrical and the upper part conical. Cut into the conical sides of the bore are two diametrically opposite channels *D* and *E*, which at their lower ends open into the bore *C*. Fitting into the upper cone is a refractory brick stopper *F* having in its head a threaded bore *G* into which fits the lower end of a rod. The stopper is formed with two diametrically opposite slots *H* and *J* of approximately the same width as the channels and in the nozzle. When such a "pot" is built into the floor of a ladle, the teeming rate can be controlled by rotating the stopper in the nozzle. In the position shown in the drawing, the nozzle is fully closed, since no metal can enter the channels past the portions *K* and *L*. By turning the stopper through 90 deg. about its axis the slots *H* and *J* are brought into register with the channels *D* and *E*, and then metal can flow at maximum rate out of the ladle. Smaller angular movements of the stopper control the rate of flow to anything between zero and the maximum. Stopper rotating gear is also shown in the specification.—*February* 16, 1955.

BEARINGS AND SUPPORTS

724,510. October 26, 1953.—SHAFT SEALING FOR BOILER CIRCULATING PUMPS, La Mont International Association, Ltd., 42, Leicester Square, London, W.C.2. (*Inventor: Gilbert Ashton Plummer.*)

The invention relates to boiler circulating pumps for high-pressure boilers with forced and controlled circulation. As the drawing shows, the overhung pump impeller *A* is connected to the pump shaft, which is protected by a sleeve *B*. Feed water at a

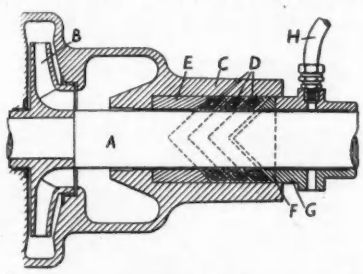


No. 724,510

temperature substantially below the hot boiler water in the circulating pump is introduced into the annular space *C* in the pump body *D*. The pressure of the water in the circulating pump being lower than the pressure of the feed water, it causes part of the feed water to flow along the pump shaft sleeve towards the pump impeller, its amount being limited by the small clearance between the restriction bush *E* and the sleeve *B*. Its flow can be further reduced by the provision of labyrinth grooves *F* in the bush. The other part of the feed water flows in the opposite direction, its amount being limited by the restriction bush *G* with small clearance. This bush is pivotally mounted in the pump body so that it can follow any vibration of the shaft, thus maintaining its flow restricting quality. On its way along the shaft, the feed water reaches the mechanical seal *H* in the chamber *J*. This chamber is flooded with condensate from the extraction pump discharge. The condensate is pure water at a very low temperature and low pressure, and serves to keep the mechanical seal cool and clean. The condensate is prevented from leaking out by the stuffing-box gland *K* with packing *L*.—*February* 23, 1955.

724,953. March 3, 1953.—STUFFING-BOXES FOR CENTRIFUGAL PUMP AND OTHER ROTARY SHAFTS, Mather and Platt, Ltd., Park Works, Manchester, 10. (*Inventor: Leslie Chandler Nuttall.*)

The object of the invention is to provide an improved arrangement of stuffing-box, packing and gland, which distributes the shaft wear over a considerable length of the shaft. In the drawing the shaft



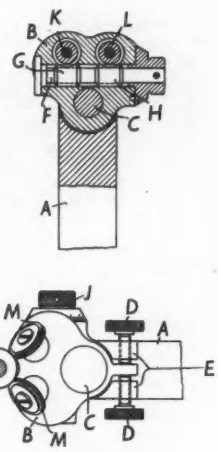
No. 724,953

A, having the centrifugal pump impeller *B* on it, passes through a stuffing-box at *C*, in which are a number of packing rings *D*, each of which passes in a zig-zag or wavy path around the shaft. Separate components *E* and *F* between the end packing rings and the bottom of the stuffing-box and the gland *G* have their faces where they abut against the packing rings shaped to the same contour as the rings. *H* is a water cooling and lubrication connection.—*February* 23, 1955.

TOOLS AND WORKSHOP APPLIANCES

724,693. March 3, 1953.—KNURLING DEVICE, Gebruder Miller G.m.b.H., Kochstrasse 6, Innsbruck, Austria, and Karl Miller, Kochstrasse 3, Innsbruck, Austria.

A knurling device according to the invention has two cylindrical knurling wheels, the edges of which detach the swarf. As will be seen from the drawing, a shaft *A*, which serves for gripping the device in the saddle of a lathe has a tool carrier *B* pivotally mounted on pin *C* and adjustable by the set-screws *D* between jaws *E*. In the tool carrier a spindle *F* having two oppositely handed threads *G* and *H* is inserted at right angles to pin *C*, and may be turned by a knurled knob having a graduated scale. The two threaded portions mate with threads on two pivot pins *K*, *L*, which carry at their projecting bevelled ends the



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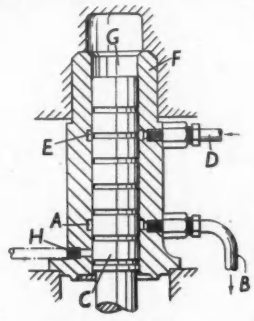
knurling wheels *M*, which are inclined by 45 deg to the pins in bushes held fast by the fixing screws. The two knurling wheels are applied against the work and are finely adjusted to height by turning the set-screws *D*. To adapt them to the diameter of the workpiece, the knurling wheels are moved apart by turning the setting knob *J*. With such a tool it is claimed that cross-hatched and flat-knurled surfaces can be formed with low radial pressure on all metals including cast iron, in workpieces ranging in diameter between 5mm and 200mm, and more.—*February* 23, 1955.

INTERNAL COMBUSTION ENGINES

724,986. April 2, 1953.—FUEL OIL INJECTION PUMPS, Crossley-Premier Engines, Ltd., Sandiacre, near Nottingham, and Arthur Cyril Yeates, of the company's address.

The invention has for its object to provide simple and effective means for preventing contamination of the lubricating oil in the pump housing or engine crankcase by leakage of fuel oil past the pump plunger, which has the usual labyrinth of annular grooves, and for ensuring adequate lubrication of the plunger where the fuel being pumped has low lubricity



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properties. As the drawing shows, an annular groove *A* in the pump barrel or pump plunger is provided at the lower end and a drain connection *B* through the pump barrel releases any fuel leakage at atmospheric pressure. Below the drain is a land or section *C* of the plunger past which fuel oil at atmospheric pressure will not flow. Lubricating oil is fed under appropriate pressure at *D* through the pump barrel to an annular groove *E* and to the plunger at a point as near to the top of the pump barrel *F* as possible. This lubricating oil, by reason of its pressure, will oppose the flow of fuel oil along the plunger from the barrel and will lubricate the plunger, so reducing wear and also sticking when fuel oils of low lubricity are used. The pressure feed of lubricating oil at *D* is made suitably high having regard to the position of the lubricating oil inlet *E* in relation to the space *G* above the pump plunger in which the fuel oil is compressed. If desired, an additional supply of lubricating oil under pressure can be provided through the barrel at *H* to the portion of the plunger below the drain connection *B*. A small amount of lubricating oil from around the plunger may mix with the fuel oil being pumped, but this may be advantageous in preventing injector needles from sticking.—*February* 23, 1955.

Catalogues

B. AND S. MASSEY, Ltd., Openshaw, Manchester, 11.—Leaflet describing double-acting drop hammers.

G.W.B. FURNACES, Ltd., P.O. Box No. 4, Dibdale Works, Dudley, Worcs.—Leaflets on continuous furnaces.

J. DAWSON FAWCETT (DARLINGTON), Ltd., Haughton Engineering Works, Darlington.—Catalogue of rotary and static dryers.

ASHMORE, BENSON, PEASE AND CO., Ltd., Stockton-on-Tees.—Brochure illustrating and describing ABP-Klonne dry gasholders.

STANDARD TELEPHONES AND CABLES, Ltd., Connaught House, 63, Aldwych, London, W.C.2.—Booklet describing 4–192 type telegraph relays.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1.—Booklet, "I.C.I. Products for Railways."

TECALEMIT, Ltd., Plymouth, Devon.—"Modern Methods," a survey of lubrication equipment, available from Tecalemit, Ltd. Price 25s.

THE DAVID BROWN CORPORATION (SALES), Ltd., Foundries Division, Penistone, near Sheffield.—Booklet on steel and bronze specifications.

THE POWER FLEXIBLE TUBING COMPANY, Ltd., Derby Works, Vale Road, London, N.4.—Catalogue of stainless steel bellows expansion joints.

CONVEYANCER FORK TRUCKS, Ltd., Liverpool Road, Warrington.—Booklet illustrating and describing conveyancer fork trucks and attachments.

BORO LABORATORIES AND APPLIANCE COMPANY, Ltd., 1, Station Buildings, Catford, London, S.E.6.—Leaflet describing the "Condesco" drip regulator.

GENERAL REFRACTORIES, Ltd., Genefax House, Sheffield, 10.—Latest publication describing "Pyrocrete" basic refractory concretes Nos. 2, 2A, 3 and 4.

CROYDON PRECISION INSTRUMENT COMPANY, 116 Windmill Road, Croydon, Surrey.—Leaflet No. 57, "Portable Wheatstone Bridge, Type P.W.2."

ENFIELD CABLES, Ltd., Victoria House, Southampton Row, London, W.C.1.—Publication E.N.103. C.M.A. Rubber and Thermoplastic Insulated Cables.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2.—Booklet describing and illustrating G.E.C. airport electrification.

COURTNEY, POPE (ELECTRICAL), Ltd., Amhurst Park Works, Tottenham, London, N.15.—Booklet describing "Opaliter," fluorescent and tungsten lighting fittings.

G.W.B. FURNACES, Ltd., P.O. Box No. 4, Dibdale Works, Dudley, Worcs.—Catalogue covering the full range of G.W.B. electric arc furnaces and ancillary equipment.

TANNIN DEVELOPMENTS, Ltd., Shell-Mex House, Strand, London, W.C.2.—Two publications, "Tannin Reduces High Steam Costs," and "Treatment of Boiler-Feed Water."

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., March 30th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Discussion Meeting on "The Maintainability of Service Equipment," Speakers A. J. B. Naish, R. B. Brenchley, G. C. Godfrey and G. W. A. Dummer, 6.30 p.m.——S. WALES SECTION: Glamorgan Technical College, Treforest, "Electronics in Industry," M. N. Lapper, 6.30 p.m.

Thurs., March 31st.—N.W. SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, "Electronic Control of Industrial Production Processes," J. A. Sargrove, followed by Annual General Meeting, 7 p.m.

CHEMICAL SOCIETY

Thurs., March 31st.—Lecture Theatre, The Royal Institution, London, W.1, "The Outlook for Industrial Atomic Energy in Europe," G. Randers, 11 a.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, March 25th.—BATH AND BRISTOL CENTRE; S.W. Electricity Board, Old Bridge Street, Bath, "Shop and Store Lighting," R. L. C. Tate, 7 p.m.

Mon., March 28th.—LEEDS CENTRE: E.L.M.A. Lighting Service Bureau, 24, Aire Street, Leeds, 1, Annual General Meeting, N.C.B. Film, "Buried Treasure," 6.15 p.m.——LEICESTER CENTRE: E. Midlands Electricity Board, Charles Street, Leicester, "The Use of X-Rays in Medicine and Industry," J. E. Hood and G. Whiteley, 6 p.m.

Tues., March 29th.—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, Discussion on "Home Lighting," 6 p.m.

Thurs., March 31st.—GLASGOW CENTRE: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, Annual General Meeting, "Plant Cultivation," W. W. Fletcher and J. B. R. Anderson, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

To-day, March 25th.—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, Annual General Meeting, 7.30 p.m.

Mon., March 28th.—W. AND E. YORKS BRANCH: The University, Leeds, 7.30 p.m.

Wed., March 30th.—LEICESTER BRANCH: Bell Hotel, Humberstone Gate, Leicester, Annual General Meeting, 7.15 p.m.

Thurs., March 31st.—S. WALES BRANCH: Grand Hotel, Cardiff, Annual General Meeting, 7.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Sat., March 26th.—WALES AND MONMOUTHSHIRE BRANCH: Newport Technical College, Clarence Place, Newport, "Foundry Developments in the Textile Industry," B. Gale, 6 p.m.

Mon., March 28th.—SHEFFIELD BRANCH: College of Technology, Pond Street, Sheffield, "Foundry Safety: Some Effects of Changing Legislation," R. F. Ottignon, 7.15 p.m.

Wed., March 30th.—LONDON BRANCH: Waldorf Hotel, Aldwych, London, W.C.1, "Safety in the Foundry," A. Talbot, 7.30 p.m.——W. RIDING OF YORKSHIRE BRANCH: Technical College, Bradford, "Sand for Floor Moulding," W. B. Parkes, 6.30 p.m.

Fri., April 1st.—TEES-SIDE BRANCH: Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, Annual General Meeting, Presentation of Awards, Apprentice Competition, followed by "Any Questions," 7.30 p.m.

Sat., April 2nd.—NEWCASTLE BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, Annual General Meeting, "Exothermic Feeding Heads," W. Stewart, 6 p.m.

INSTITUTE OF FUEL

To-day, March 25th.—SCOTTISH SECTION: Royal Technical College, Glasgow, Annual General Meeting, followed by Films, 7 p.m.

Mon., March 28th.—N.E. SECTION: Cleveland Institute, Middlesbrough, "Producer Gas," G. D. Milner, 6.30 p.m.

Fri., April 1st.—S. WALES SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, "Start of the National Industrial Fuel Efficiency Service," W. A. Macfarlane, 6 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., March 28th.—WEST OF ENGLAND SECTION: Smith Brothers Assembly Room, Westgate Buildings, Bath, "Some Factors in the Selection of Machinery for Cargo Liners," L. Baker, 7.30 p.m.

Tues., March 29th.—85, Minories, London, E.C.3, "U.S.S. 'Timmerman': An Advanced Design Destroyer," D. G. Phillips, 5.30 p.m.

INSTITUTE OF METALS

Tues., March 29th.—OXFORD LOCAL SECTION: Cadena Cafe, Cornmarket Street, Oxford, Annual General Meeting, Discussion on "Non-Destructive Testing," introduced by E. G. Stanford, 7 p.m.

Tues. to Fri., March 29th to April 1st.—SPRING MEETING: *Tuesday:* Royal Institution, Albemarle Street, London, W.1, "The Nature of the Real Crystal," F. C. Frank, 7 p.m.; Army and Navy Club, Pall Mall, London, S.W.1, Council Dinner, 8.30 p.m. *Wednesday:* Church House, Great Smith Street, London, S.W.1, Annual General Meeting, 10 a.m.; Convocation Hall, Discussion on "Refractories for Low-Frequency Induction Furnaces," 2.30 p.m.; Bishop Partridge Hall: Discussion on "Fatigue," 2.30 p.m.; Institute of Physics, 47, Belgrave Square, London, S.W.1, Informal Conversazione and Exhibition, 8 p.m. *Thursday:* Church House, Great Smith Street, London, S.W.1, Hoare Memorial Hall: Symposium on "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys," 10 a.m. to 12.45 p.m., and 2.30 p.m. to 4.30 p.m.; Bishop Partridge Hall, Discussion on "The Constitution of Uranium Alloys," 10 a.m.; Discussion on "Twinning," 2.30 p.m.; "Deformation and Fracture of Zinc," 3.30 p.m.; Grosvenor House, Park Lane, London, W.1, Dinner and Dance, 7 p.m. *Friday:* Visits for Members and Male Guests.

INSTITUTE OF REFRIGERATION

Thurs., March 31st.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Symposium on "Modern Trends in the Storage of Fruit and Vegetables," Papers by W. H. Smith, W. G. Burton and J. C. Fidler, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., April 4th.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Roads and Commercial Transport," G. Charlesworth, 7.30 p.m.

INSTITUTE OF WELDING

To-day, March 25th.—BIRMINGHAM BRANCH: Midland Institute, Paradise Street, Birmingham, 1, "Principles of Nozzle Design," R. E. Jahn, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., March 29th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Technical Developments in the Lubrication of Tractors," E. S. Bates, 2.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, March 25th.—YORKSHIRE ASSOCIATION: Grand Hotel, Sheffield, "Scale Model Investigation of Hydraulic Engineers' Problems," W. Eastwood, 7 p.m.

Tues., March 29th.—AIRPORT MEETING: Great George Street, Westminster, London, S.W.1, "The Extension of the Runway at R.N. Air Station, Belfast," L. R. Greenaway and J. Callagin, 5.30 p.m.

Thurs., March 31st.—YORKSHIRE GRADUATES' AND STUDENTS' SECTION: Civic Hall, Leeds, Annual General Meeting, 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, March 25th.—SCOTTISH CENTRE: Caird Hall, Dundee, "Courier to Carrier in Communications," T. B. D. Terroni, 7.30 p.m.

Mon., March 28th.—LONDON STUDENTS' SECTION: Savoy Place, London, W.C.2, "An Introduction to the Transistor," A. U. Bryant, 6.30 p.m.——S. MIDLAND CENTRE, RADIO GROUP: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Recent Search for, and Salvage of, the 'Comet' Aircraft Near Elba," C. G. Forsberg and C. G. Macneice, 6 p.m.

Wed., March 30th.—RADIO AND MEASUREMENTS SECTIONS: Cafe Royal, Regent Street, London, W.1, Joint Dinner-Dance, 7 p.m.

Thurs., March 31st.—ORDINARY MEETING: Savoy Place, London, W.C.2, "Electrical Energy from the Wind," E. W. Golding, 5.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Fri., April 1st.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, Discussion upon the Currently Proposed Road Programme, Speakers C. T. Brunner ("The Economic and Financial Angle"), A. C. Newman ("The Constructional Angle"), and Sir E. Owen Williams ("The Design Angle"), 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 25th.—GENERAL MEETING, HYDRAULICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Hydraulic Transport of Solid Material in Pipes," R. C. Worster and D. F. Denny, 5.30 p.m.——SCOTTISH GRADUATES' SECTION: Royal Technical College, Glasgow, Annual General Meeting, "A Locomotive Building Firm in Retrospect," E. F. Clark, 7.30 p.m.

Mon., March 28th.—DERBY A.D. CENTRE: Rolls-Royce Welfare Hall, Derby, "Nuclear Reactors and Power Production," Sir Christopher Hinton, 7 p.m.

Tues., March 29th.—1, Birdcage Walk, Westminster, London, S.W.1, Special Meeting for Consideration of Draft New By-Laws (Corporate Members only), 5.30 p.m.——MIDLAND BRANCH: College of Technology and Arts, Rugby, "Some Factors in the Selection of Machinery for Cargo Liners," L. Baker, 6.30 p.m.

Wed., March 30th.—E. MIDLANDS BRANCH: Royal Hotel, Grimsby, "Inspection, Explosion and Breakdown of Boilers and Pressure Vessels," J. Eyers, 7.30 p.m.——SOUTHERN BRANCH: Royal Aircraft Establishment Technical College, Farnborough, "Tracer-Controlled Machine Tools," H. C. Town, 7.30 p.m.——YORKSHIRE BRANCH: Mansion House, Doncaster, "The Application of Shock-Absorbers and Buffers," A. P. Fitzjohn, 7 p.m.——WESTERN GRADUATES' SECTION: Royal Ordnance Factory, Bridgwater, "Tube Bending Machinery and Methods," R. Jall, 6.30 p.m.

Thurs., March 31st.—WESTERN A.D. CENTRE: Technical College, Gloucester, "Some Aspects of the Design and Performance of Small Diesel Engines," B. W. Millington and M. N. Howarth, 7.15 p.m.

Fri., April 1st.—GENERAL MEETING, APPLIED MECHANICS' GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "An Electrolytic Tank Investigation into Stepped Thrust Bearings," C. F. Kettleborough; "Journal Bearing Performance under Sinusoidally Alternating and Fluctuating Loads," G. S. A. Shawki and B. Freeman; "Bending Stresses in Spur Gear Teeth: Proposed New Design Factors Based on a Photo-Elastic Investigation," M. A. Jacobson; "Prediction and Measurement of Vibration in Marine Geared Shaft Systems," by the late H. G. Yates; "The Promotion of Fluid Lubrication in Wire Drawing," D. G. Christopherson and H. Naylor; "Experimental Investigation of the Mechanics of Wire Drawing," J. G. Wistreich, 2 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., March 28th.—SHEFFIELD GRADUATE SECTION: Royal Victoria Station Hotel, Sheffield, Graduate Award Paper, followed by Film Evening and Annual General Meeting, 6.30 p.m.

Tues., March 29th.—LUTON SECTION: Small Assembly Room, Town Hall, Luton, "Management and Production," H. Bainbridge, 7.15 p.m.

Wed., March 30th.—SHREWSBURY SECTION: Technical College, Shrewsbury, Annual General Meeting, followed by a Film Programme, 7.45 p.m.

Thurs., March 31st.—CORNWALL SECTION: Camborne School of Mines, Camborne, Chairman's Address, "Some Notes on the History and Practice of Metal Perforating," H. M. Sawyer, 7.15 p.m.——S. WALES AND MONMOUTHSHIRE SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, "Economics in Production Engineering," F. A. Wells, 7 p.m.

INSTITUTION OF SANITARY ENGINEERS

Wed., March 30th.—SESSIONAL MEETING: Caxton Hall, Westminster, London, S.W.1, "Sanitary Engineering: Sundry Impressions," Lloyd Ackers, 6 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., March 28th.—MANCHESTER SECTION: Engineers' Club, Albert Square, Manchester, "Application of Rubber to Fibres," T. S. McRoberts and C. D. Hogg, 6.45 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 25th.—ORDINARY MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "Amateur Telescope Making," R. D. Gifford, 7 p.m.

Fri., April 1st.—FILM EVENING: Pepys House, 14, Rochester Row, London, S.W.1, "The Miner," "Plan for Coal," "The Scraper Box" and "Coalmining To-day," introduced by Lambton Wilkinson, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, March 25th.—Engineers' Club, Albert Square, Manchester, Annual General Meeting, "Engineering Problems Associated with Production and Operations at Low Temperature," H. E. Charlton, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, March 25th.—Mining Institute, Newcastle upon Tyne, "The Geometrical Size Effect in Notch Brittle Fracture," A. A. Wells, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., March 31st.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "Application of Aerial Survey to the Economic Development of a Country," T. D. Weatherhead, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 4th.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Why Put Your Money in Land?" W. M. Balch, 5.30 p.m.

ROYAL SANITARY INSTITUTE

Wed., March 30th.—SESSIONAL MEETING: Town Hall, Worthing, "Refuse Disposal at Worthing," J. Wilkinson and G. A. Frake, followed by Films 10.15 a.m.; Afternoon Visit to East Worthing Refuse Disposal Works.

ROYAL SOCIETY OF ARTS

Mon., March 28th.—CANTOR LECTURE: John Adam Street, Adelphi, London, W.C.2, "The Mechanical Properties of Metals: Fatigue," P. L. Teed, 6 p.m.

Wed., March 30th.—John Adam Street, Adelphi, London, W.C.2, "Recent Developments in Deep Sea Diving," Sir Robert H. Davis, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Thurs., March 31st.—SHEFFIELD GROUP: Cavendish Room, Grand Hotel, Sheffield, "Bunching of Furnaces," R. Soft, 6.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., March 30th.—CORROSION GROUP: Convocation Hall of Church House, London, S.W.1, "Attention to Corrosion in the U.S.A.," F. L. Laque, 6.30 p.m.

Thurs., March 31st, and Fri., April 1st.—CORROSION GROUP: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Symposium on "The Protection of Structural Steel." *Thursday:* "Painting and Protection of Steel Structures," F. Fancutt; "Current Good Painting Practice for Steel Structures in U.S.A.," J. Bigos; "The Preservation of Steel on Gasworks in Great Britain," L. A. Ravald, 9.30 a.m. to 1.0 p.m. "The Principles of Protective Painting," G. Déchaux; "Physical Examination of Paints in Relation to their Practical Performance," H. W. Talen, 2.30 p.m. to 4.15 p.m.. Symposium Dinner, Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2 6.30 p.m. for 7.0 p.m. *Friday:* "Exposure Tests of Paints and Zinc Coatings in Sweden," K. F. Tragardh and P. Nylen; "The Formulation of Priming Paints for Structural Steel," J. C. Hudson and J. F. Stanners; "Results of Researches of the Belgian Corrosion Committee," M. van Rysselberge and D. Bermane, 9.30 a.m. to 1.0 p.m. "Practical Experience with Sprayed Metal Coatings," W. E. Ballard and F. A. Rivett; "The Use and Weldability of Aluminium-Sprayed Steel," H. F. Tremlett and W. A. Johnson; "Protection Problems in Chemical Factories," F. R. Himsworth, 2.30 p.m. to 5.0 p.m.

SOCIETY OF INDUSTRIAL ENGINEERS

Fri., April 1st.—Management House, 8, Hill Street, London, W.1, "What Industry Expects of Education," Cecil Potter, 7 p.m.